THE STANDARD CYCLOPEDIA OF MODERN AGRICULTURE AND RURAL ECONOMY

1 3 4

CONIFERS

1 Scotch Pine (*Pinus sylvestris*), 2 Larch (*Larix europaea*)
3 Spruce (*Picea excelsa*), 4 Douglas Fir (*Pseudotsuga Douglasii*).

THE STANDARD CYCLOPEDIA OF MODERN AGRICULTURE AND RURAL ECONOMY

BY THE MOST DISTINGUISHED AUTHORITIES AND SPECIALISTS UNDER THE EDITORSHIP OF

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The classic series of articles on insects by the late John Curtis have been embodied in the work, revised by Professor F. V. Theobald and Mr. Cecil Warburton, M.A., and bear the initials of J. C. and F. V. T. or C. W.

In like manner the great botanical articles of the late Professor John Lindley, which, like Curtis's articles above mentioned, were contributed to Morton's *Cyclopedia of Agriculture*, have, under Professor A. N. M'Alpine's revision, been embodied over the initials J. L. and A. N. M'A.

THE STANDARD CYCLOPEDIA OF MODERN AGRICULTURE

Cocoanut, or **Coconut,** is the fruit of the palm *Cocos nucifera*, a native of the islands of the Indian and Pacific Oceans, now cultivated throughout the Tropics (up to latitudes 25° N. and S.), but never remote from maritime influence. In the basins of great rivers it may be found 250 miles inland, but usually it does not penetrate farther than 50 to 80 miles from the seashore. It grows to a height of 60 to 100 ft., and the stem is usually straight and terminated by a crown of feathery leaves. In five to ten years after planting it begins to bear fruit. It throws out a spathe and leaf every month, the flowering spikes of which come to bear from 10 to 25 nuts, hence each palm may afford from 100 to 300 nuts a year, and continue so to yield for seventy to eighty years. The nut consists of a fibrous pericarp, a hard shell, and an edible kernel. From the pericarp the fibre known as *coir* is prepared. The kernel in its young state consists chiefly of a liquid known as the *milk*, which sets, as the nut matures, into an albuminous lining to the shell. This, on being removed and dried, is known as *copra*. From the copra is expressed an oil of considerable value, and the cake (*poonac*) left behind (after removal of the oil) is extensively utilized as an article of cattle food.

For the purpose of propagation, large well-formed nuts are selected and stored for six weeks or so, then planted in a trench about a foot apart, and assorted so that they may be just below the surface. Within the trench are placed ashes and common salt as manure. From two to six months later the seedlings thus obtained are removed to their permanent positions, the beginning of the rains being selected as the transplanting season. In Java and the South Sea Islands ripe nuts are hung up for some months under the eaves of the houses, or until sprouting takes place. This dispenses with the trouble and expense of germination in a nursery, and has the advantage of allowing weakling plants to be readily seen and thus rejected. In successful plantations the palms are not nearer each other than 25 to 30 ft. each way. It is sometimes maintained that a second transplanting is beneficial, namely, when plants are only a few years old, the holes into which they are to be deposited being specially prepared, left exposed for some time, and manured. The yield very largely depends on soil, climate, and method of cultivation, but a fair average would be from 70 to 100, or say up to 5000 to the acre, which at 4 lb. for each nut would come approximately to from 6 to 8 tons. The forms of the plant grown are very largely the result of adaptations to the purpose desired, though climate and soil often favour the development of one property more than another.

If intended to be tapped for juice, the fruits are not allowed to be matured, a stem therefore that affords a high quantity and rich quality of sap is thus desired. If the production of fibre from the pericarp (coir) be the object aimed at, long fruits with strong fibres, such as the South Sea plant yields, or a special fruit known to possess fine coir, such as that of the Cochin palm, may be the guiding factors. But ripe, edible nuts give very coarse, inferior fibre, and since only fully ripe fruits are as a rule used in the preparation of copra and oil, it follows that a combination in the production of fibre and oil is impossible. One of the most interesting of the modern developments of the cocoanut is the formation of vegetable butter from the oil. This is claimed as superior for culinary and baking purposes to butter, lard, or tallow, and much cheaper. Confectioners, moreover, find it a sufficient substitute for the expensive cacao butter, the traffic in which has for some years been declining. With a large section of the inhabitants of tropical countries the cocoanut is an article of daily food. Natives of all classes consume the soft creamy pulp and cool refreshing milk of the green nuts. The dried kernels, in place of being pressed for oil, may be simply rasped, and in this form put into curries or worked up in confectionery. The fresh juice drawn from the stem is consumed as a beverage, toddy (*tari*), or by evaporation is reduced to sugar, or by distillation is converted into spirit (*arak*). To the people of regions where at all abundant, the cocoanut is one of the most valuable of plants, and affords practically all the necessities of life. [G. W.]

Cocoanut Cake.—This cake is made from the fruit of the Cocoanut Palm (*Cocos nucifera*), being the residue left from the manufacture of cocoanut oil after pressing the oil out from the kernel (see above art.) It is not largely used in feeding, and probably one single mill in Liverpool supplies all that is required in this country. On the Continent it is used more extensively. Cocoanut cake is, however, a food in favour in some quarters, and mainly for milk-

ing cows. *It is a food fairly rich in fat, and has a pleasant odour when fresh. The oil is, however, rather apt to turn rancid, and to impart acidity to the cake.* The following analysis represents the general composition of the cake:—

Moisture	7·97
Oil	10·98
[1] Albuminous compounds	20·38
Mucilage, sugar, digestible fibre, &c.	42·43
Woody fibre	12·21
Mineral matter	6·03
	100·00

[1] Containing nitrogen ... ... 3·26

Cocoanut cake has an albuminoid ratio of 1:4. It is esteemed a good food for the production of both milk and butter, and is readily taken by stock; about 3 lb. a day is an ordinary feed for a milking cow. It contains on an average 1·40 per cent of phosphoric acid and 2 per cent of potash, the ash consisting largely of phosphates of lime and potash. [J. A. V.]

Cocoon.—A cocoon is the outer covering or investment in which the pupal stage of many insects, such as the bombyces, sawflies, and moths, is passed. It consists of silken threads derived from the salivary glands of the larva, which may be either loosely woven together to form an open network, or elaborated into a compact oval ball. Minute particles of sand and wood may be incorporated in this silken sheath. It is from the cocoon spun by the silkworm that raw silk is obtained [R. H. L.]

Codling Moth, a species of moth, the larvæ of which feed on apples. See CARPOCAPSA POMONELLA.

Cœlinius niger, a small hymenopterous fly, parasitic upon Chlorops. The eggs are supposed to be laid in the maggots, in the stem and spathes of the green corn, feeding upon the former as soon as they hatch, and undergoing their transformations in the indurated skin of the Chlorops maggot. (See illustration under art. CHLOROPS) The Cœlinius hatches several days before the Chlorops, and eats a hole through the leaves to escape. There are several British species, which are abundant from midsummer to Michaelmas in meadows; the one bred from the corn Chlorops is named *Cœlinius niger*, being of a pitchy colour; the two long jointed antennæ, head, and trunk are glossy black; the abdomen is narrowed at the base; the ovipositor of the female is scarcely visible; the four wings are transparent; stigma brown; legs slender; fore pair ochreous, with dusky feet. [J. C] [F. V. T.]

Cœnurus.—The name given to a bladder-like cyst or body (*Cœnurus cerebralis*) sometimes found in the brain of sheep, and which gives rise to the disease known as 'staggers'. It is one of the stages of the development of the tapeworm *Tænia cœnurus* occurring in the dog. See BLADDERWORMS, STAGGERS, TAPEWORMS.

Coffee (*Café*, Fr.; *Kaffee*, Ger.).—THE PLANT.—The coffee plant may be described as a large evergreen perennial bush or small tree, possessing oblong, pointed, smooth, shining, opposite leaves, and conspicuous interpetiolar stipules. The flowers are pure-white, richly scented, and formed copiously along the young wood in axillary clusters. The fruits are nearly sessile, succulent 'cherries' that contain ordinarily two large seeds in place of a stone. The seeds ('coffee beans') constitute the coffee of modern commerce and are plano-convex, with a longitudinal furrow on their flat surfaces, which are placed facing each other within the fruit pulp. Coffee belongs to the nat. ord. Rubiaceæ, and has been placed in a special genus named Coffea.

The regions of wild and cultivated species lie within the Tropics and between 20° N. and 20° S., or, owing to local favourable conditions, perhaps a few degrees still farther to the south. The coffee plant is thus essentially tropical—very much more so than the tea plant—but it manifests a wonderful power of endurance. It requires a rich loamy soil, and has a distinct preference for a rocky situation. Accordingly it is most successfully raised on the hills, and ascends from 1000 to approximately 5500 ft. above the sea level, but is found on lower altitudes as it passes north or south. It is instantly restricted by temperature, and can never be grown where subjected to less than 55° F. or much over 85° F Sea breezes are advantageous, and in the hotter areas of its cultivation shade is indispensable. In hot, damp situations it luxuriates, so far as leaf production is concerned, but the finest coffee is obtained from the higher altitudes, where a definite but not too abundant supply of moisture prevails. A well-distributed rainfall of from 75 to 150 in is considered necessary. From December to March may be dry. But the coffee plant is instantly killed by stagnant water, and thus necessitates a complete system of drainage when such does not naturally exist. High winds are injurious, and when prevalent (from a fixed direction) protecting hedges become necessary.

DISTRIBUTION OF THE PLANT.—Down to the year 1690 the world's supply of coffee came from Arabia and Abyssinia. In that year live seeds having been conveyed to Batavia (Java), a plant was shortly after taken to Amsterdam, and in 1712 the Dutch presented a seedling to Louis XIV. A little later (1720) seedlings obtained from that plant were sent to Martinique, Surinam, and ultimately throughout the Tropics of the New World. It seems probable that about the same time, or possibly somewhat earlier, a Mohammedan pilgrim, Baba Budan, had conveyed live seeds direct from Mecca to Mysore (India). By the middle of the 18th century it may be accepted that coffee cultivation had been established throughout the Tropics. The Dutch East India Company pioneered the modern trade, and in time the new areas produced far more than the ancestral regions (Arabia and Abyssinia). Improvement in quantity and quality of necessity rapidly extended consumption, and soon coffee became one of the most popular of all beverages, and passed from the position of an occasional luxury to that of a daily necessity. It may thus be said, and with much force, that from the progeny of the single plant sent from Batavia to Holland is

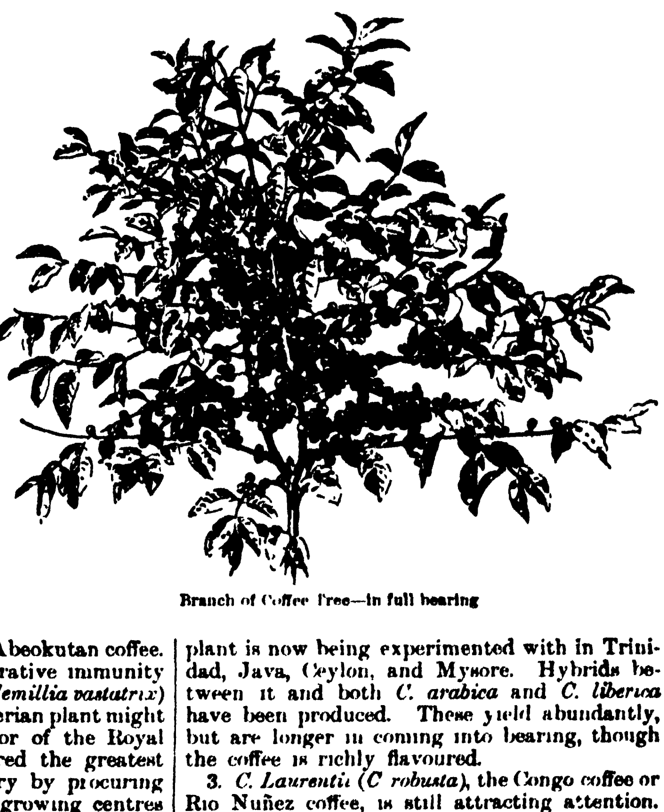
now obtained more coffee than from all other sources combined.

Species and Varieties.—It may now be desirable to turn very briefly to the consideration of the botanical features of special interest. The most important species is known as *Coffea arabica*, but it is probable that while first definitely cultivated for its fruits in Yemen (Arabia), that plant was in all probability originally a native of Abyssinia. This much is certain, no botanist has mentioned the discovery of wild coffee in Arabia, though several wild species have been recorded as plentiful both on the east and the west sides of Africa. More than one of these have been described as also met with under cultivation on account of its coffee-yielding seeds. But the so-called Arabian plant is admittedly the best of all the species, and but for its liability to disease would be unquestionably preferred in every locality where its cultivation was at all possible. The desire to overcome the losses sustained by disease has led coffee planters to cultivate other forms, and to strive after the production of hybrids which, while preserving the rich flavour and prized aroma of the Arabian stock, would have engrafted to them the greater strength and disease resistance of the less-prized forms.

The more promising of the supplementary stocks may now be briefly indicated.

1. *C. liberica*, a native of tropical West Africa, Liberia, Angola, &c. This plant in its indigenous home occurs in small plots along the banks of streams, and the produce is known in trade as Liberian or Abeokutan coffee. Its hardier growth and comparative immunity from the great fungal scourge (*Hemillia vastatrix*) has led to the belief that the Liberian plant might prove invaluable. The Director of the Royal Botanic Gardens, Kew, rendered the greatest possible service to the industry by procuring and transmitting to the coffee-growing centres of the British empire supplies of the seeds of this species. It was eagerly cultivated, but while found useful in many directions, cannot be said to have fulfilled the high expectations entertained of it. It has been proved to thrive best on the lower and moister tracts of the coffee area—tracts where Arabian coffee would not grow, or at all events less profitably than the Liberian stocks. It has accordingly been fairly extensively adopted as the coffee plant to be grown in certain portions of the West Indies, the Malay Peninsula, North Borneo, Sumatra, and Java. Moreover, for some years past, numerous hybrids have been produced, and often claimed as possessing special merits. So again the Liberian plant is frequently upheld as having given great strength to the Arabian plant when grafted on to it, the Liberian roots being able to resist eelworm parasite, that often does such serious damage to coffee. On low ground the harvest is abundant, the fruits large, but the berries are more difficult to clean, and unless very carefully and slowly dried fetch a much lower price. But it seems possible Liberian coffee might attain greater popularity were it used as a special coffee with definite properties of its own, instead of being employed to mix with finer grades.

2. *C. stenophylla*, the Highland coffee of Sierra Leone. This interesting species was at one time thought likely to prove but a variety of *C. arabica*. Seeds were issued from Kew, and the plant is now being experimented with in Trinidad, Java, Ceylon, and Mysore. Hybrids between it and both *C. arabica* and *C. liberica* have been produced. These yield abundantly, but are longer in coming into bearing, though the coffee is richly flavoured.



Branch of Coffee Tree—in full bearing

3. *C. Laurentii* (*C. robusta*), the Congo coffee or Rio Nuñez coffee, is still attracting attention. It yields a good berry, and enjoys a practical immunity from leaf (fungal) disease. It prefers banks of streams, and open, moist country, but has by no means been so easily acclimatized as the Liberian.

4. In addition to these, there are several other species, especially those from Abyssinia, that are engaging attention, but none have as yet proved either so easily grown or so profitable as the true Arabian plant. In fact, it is generally upheld that the varieties and races of *C. arabica* are quite as extensive and varied as the planter need desire. Hence success may be best attained by discovering the form or forms of that plant suited to the climate, soil, and resources available. It would take much space to mention,

however briefly, all the cultivated races that are known, but the following will give some idea of their diversity: (*a*) *Vermelho*, a red-fruited coffee of Central America; (*b*) *Amarello*, a yellow-fruited plant of Brazil; (*c*) *Maragogipe*, Upland Brazilian, a plant nearly as large as Liberian and very prolific. According to some writers, this is a hybrid between *C. arabica* and *C. Laurentii*. (*d*) *Leucocarpa*, a white-fruited plant found originally in Sierra Leone; (*e*) *Leroy of Reunion*, or *Pointed Bourbon*, a plant more hardy than Mochas, has short, crowded branches and pointed seeds; (*f*) *Cannon's Mysore* has round, heavy seeds, branches ascending. (*g*) *Coorg*; this has a large flat seed, and is easily propagated. Under this there are several sub-races, such as *Chick*, *Golden Drop*, *Nalkund*—these are rapidly displacing Cannon's Mysore from the Indian plantations. (*h*) Java; this bears branches less horizontal than Brazilian, and the terminal leaves are greenish yellow, not brownish as in the Brazilian plant.

CULTIVATION.—*The Nursery*.—The selection of stock is one of the most important subjects that should engage the attention of the planter. Immunity or practical immunity from disease should be an even more earnest consideration than even special quality or superabundant yield. The difficulties of the industry preclude risks being taken that might be obviated by personal knowledge and care. It is on this account that the nurseries should be as near as possible to the planter's house, so as to ensure constant supervision and intelligent study of the young plants raised from seed. Uniformity in stock, both as to quality, size of berry, and season of ripening, should be carefully observed. Any departures from the previously agreed upon plant should be instantly removed from the nursery, though no opportunity need be lost in studying new sports that may appear. The discovery of forms of plant directly suited to the climate, soil, and method of treatment should be the aim of every planter.

Laying out the Estate.—Coffee is most generally raised from seed sown in nurseries, but seed at stake is also frequent; that is to say, stakes are driven into the ground all over the new plantation to mark the places where plants are intended. A few seeds are sown near each stake, and the weaker seedlings are removed, leaving the one intended to be cultivated. The land of the new plantation should be dug all over as deeply as possible, since deep trenching after the roots form is next to impossible. At this stage, drains where found desirable should be furnished.

Propagation.—During the first few years the plantation should be dug all over as deeply as possible. When the seedlings are about a year old (or say when 1 to 3 ft. high) they are planted out into their permanent positions. It is preferable to select dull weather for this operation. The seedlings are at the same time usually protected by some temporary shade, provided either by matting or leaves tied on the poles (stakes) alongside of the seedlings. Much difference of opinion prevails as to the distance apart that the estate should be lined. *This will be determined by the nature of the stock selected; the system of cultivation to be pursued (more especially the degree of pruning to be followed); the character of the soil; the degree of shade (that exists or is intended to be provided); and lastly, the position of each plot (exposed hillside or confined valley). With small bushes, a distance of 5 ft. apart each way is often deemed sufficient, while with the large bush (or tree) system as much as 15 ft. may be allowed each way, plant from plant. It is accordingly a problem of some importance whether catch crops should or should not be cultivated* between the rows of coffee to afford the shade often specially provided by trees of no other value (Erythrina, &c.) than the shade they afford. Where liability to borer (parasite) exists, it seems the universal belief that shade as a protective measure is indispensable.

So, again, considerable difference of opinion exists on the subject of the method of subsequent tillage, weeding, pruning, and manuring that should be followed. Manure is often beyond the means of the smaller and poorer cultivators. Many accordingly hold that a system of mulching the surface with leaves, weeds, &c., is the preferable course, more especially where the necessity exists for measures to preserve the soil against surface wash on the one hand, and parching, dry, hot winds on the other. But high cultivation has its advocates, and farmyard manure where obtainable in sufficient quantity is held to be the most desirable dressing. On steep hillsides terracing is often followed, or a system of shallow pits, to catch and retain near the plants the surface wash, is pursued. Systematic weeding is generally considered essential, but the opposite view is sometimes advanced, namely, that the weeds usually present in coffee estates do little injury to the plants, while they serve the useful purpose of a protecting covering to the soil. Recently it has been recognized that the encouragement of leguminous weeds might serve the same purpose as a clover rotation in European agriculture.

With regard to pruning, two opposite schools exist, namely, severe and periodic, the bushes being made to assume and preserve a required shape and form; the other, no pruning at all. The one might be characterized as the transverse, the other as the vertical system. In the former the bushes cover the entire estate and are kept low, the primary branches being made to spread horizontally, so that the fruiting surface is on the top, as if covering an umbrella. In the latter, open spaces exist around the bushes, the fruiting surface being from the ground to the topmost twig.

Seasons and Yield.—A coffee estate comes into bearing about the third year, and is in full yield in its fifth. Under favourable conditions it may go on yielding annual crops for forty to sixty years. But many trees are exhausted at a much earlier date, say after giving ten to fifteen full crops. The endurance of an estate depends upon the treatment it receives, and upon whether or not the plants have been seriously attacked by pests and blights. A system of filling up vacancies must be accepted as part

in the annual programme of operations, and if successfully accomplished there is no reason why an estate should have any limit fixed as to its endurance. With a continuance of healthy young plants and a systematic renovation of the soil, a coffee estate may be accepted as a permanent investment.

Under certain climatic conditions the plant may blossom at any season of the year, but in most countries there are two or three seasons, one being the chief. It is the aim of the planter to obtain a stock that will flower simultaneously and give its crop at the period of year (for each estate) most advantageous. Rain during flowering is very unfavourable, but after the fruit has set, a shower or two is highly beneficial. The variability of seasons may be illustrated by Brazil. The crop in Rio de Janeiro is in the market a month before that from São Paulo (April and May), while from Braganza and Atabaia it is not seen until October. In India the blossoms appear in March, and the fruit ripens in October to January, and this range is often extremely local and governed by influences of a very restricted character.

The fruits are either hand-picked (in the horizontal system of production) or are shaken from the bushes (in the vertical), or are allowed to fall on the ground when fully ripe (the system followed in Arabia). In India it is believed that the sooner picked after colour appears the better, but it is fully admitted throughout the coffee-producing area that much of the flavour of coffee depends on the degree of ripeness of the fruit. In Brazil the cherries are shaken from the bushes, but it is admitted this course is a consequence of insufficient labour, not of choice.

Manufacture.—The ripe coffee fruit is called technically the 'cherry', the contained seeds are the 'berries'. When only one seed is present it is the 'pea berry'. The succulent outer rind is the 'pulp' and the inner layer the 'parchment', while within the parchment and adhering firmly to the seeds is the 'silver skin'. The pulp is removed by either of two methods: (a) the ancient or dry system, the cherries are dried, then beaten until the husk is separated. (b) The modern or wet system; the fruits on being brought to the factory are thrown into a vat full of water. The ripe cherries sink to the bottom, and the unripe and diseased ones float on the surface. The latter are removed as tailings, and the former are drawn through an opening in the vat, and pass to a pulping machine, which tears off the succulent outer layer and allows the berries with their adhering succulent parchment to pass through.

The next stage is the removal of a large portion of the sticky mucilaginous substance of the parchment. This is done by causing fermentation to be set up for twelve to forty-eight hours (according to the temperature of the locality), and thereafter washing the berries thoroughly. After this has been done, the berries are carefully dried and assorted, often being hand-picked. The colour of the berry is in the trade one of its standards of merit, and this depends upon the age of the fruit and the method of drying.

After being dried, picked, and assorted, the berries are packed, and consigned either to the merchants 'in parchment' or to the hulling mills. These may be on the estates, or at the ports of shipment, or in the consuming country. The loss in weight between coffee in parchment and after being milled is about one-half. But it is held that the double freight paid on coffee in parchment is more than compensated for through the preserving property of the closely encasing parchment and silver skin.

Trade.—The value of coffee largely depends on the form of the berry, its size, colour, smell, flavour, and the uniformity of the parcel. And it would seem as if some of these tests are by no means arbitrary, but are actually indicative of merit. It has, for example, been shown that a chemical standard based on the percentage of caffeine would by no means be of value. Average samples of *C. arabica* contain from 0·83 to 1·60 per cent, *C. liberica* from 1·06 to 1·45, *C. stenophylla* from 1·52 to 1·70, while some of the Madagascar species contain no caffeine at all. On the other hand, with a series of samples examined it was found that those with the highest specific gravity contained the most nitrogen and phosphoric acid, and these brought the highest prices. Colour depends upon the degree of ripeness much more than on the nature of soil or race of plant grown. As a general rule, Old World coffees are inclined to shades of yellow, and New World grades run to greens. Weight decreases with age and overdrying. Odour and flavour (due to the presence of an aromatic oil) alone give the key to quality, and hence can be determined by experts only, though they are developed by the process of roasting. Storage is said to improve the flavour, though it lowers the weight.

The following are the chief producing countries, assorted under eight groups, placed in two sections according to their approximate positions.—

South of the Equator—

1. *Brazil.*—Coffee production may be viewed as confined to the provinces of São Paulo, Rio de Janeiro, Minas Geraes, and Espiritu Santo.

2. *Java.*—Under this assemblage is included (in addition to Java proper) the coffees of Sumatra, Celebes, Borneo, New Guinea, and Queensland. Some of the Javan berries hold a high position.

3. *Africa (East) and Madagascar, &c., also (West) Angola.*—Coffee is the most important single article of trade from British Central Africa. Natal has also begun to export, and Madagascar, Reunion, and Mauritius may be viewed as fairly old countries of supply.

North of the Equator—

4. *Central and South America.*—Guatemala, Costa Rica, Nicaragua, Honduras, &c., cultivate and export coffee. In Venezuela and Colombia coffee is grown extensively, and the export is considerable. Ecuador, Peru, and Bolivia also grow the berry, the last-mentioned being often spoken of as producing one of the finest grades in the world, though but little known to Europe, since hardly any is exported.

5. *West Indies.*—The Blue Mountain coffee of

Jamaica still holds a high position. It is grown at an altitude of 3000 to 4500 ft. Haiti (San Domingo) in point of quality is perhaps the most important in this group, but others may be mentioned, e.g. Cuba, Porto Rico, Trinidad, &c.

6. *India and Ceylon.*—Coffee is mainly produced in South India, and one-half of the area is in Mysore. The cultivation in Ceylon has been reduced to small dimensions, tea having been substituted some time ago, as a consequence first of 'bug' then of 'leaf disease' rendering coffee unprofitable. The Indian coffee is mainly of a high class, much of the produce finding its way into the markets of Europe under the name Mocha.

7. *Africa (West), Liberia, Sierra Leone, Nigeria, &c.*—This is mostly known as Abeokuta coffee.

8. *Arabia and Abyssinia.*—The coffee of Yemen takes the name of its port of shipment—Mocha, but the supply available for Europe has for many years been steadily shrinking. The bulk is purchased on the bush by traders, who collect, cure, and ship it themselves to Turkey and Egypt.

Prices.—The keen competition that has characterized the coffee industry of the world for the past twenty years or so has caused a serious decline in price, and this with diseases and pests has lowered the profits of planting, until it may fairly be said the past few years have witnessed a tendency to curtail rather than increase the area of production. This may be exemplified by the returns published for India. If the prices realized in 1874 (just after the collapse of the Ceylon industry) be taken as 100, the price in 1877 was 110*s.* 0½*d.* per cwt.; ten years later (1887) it averaged 94*s.* 9½*d.*; still ten years later (1897), 94*s.* 8*d.*; and lastly in 1907 it stood at 58*s.* 6*d.* It is therefore no matter for surprise that economies often injurious alike to the interests of the coffee planter and the coffee consumer should have become necessary.

Production and Consumption.—The world's supply of coffee has been estimated at from 15 to 16 million bags (of 132 lb. weight), of which Brazil furnishes 11¼ million bags. The greatest coffee-consuming countries are Holland (18·82 lb. to head of population in 1900), Belgium (10·53 lb.), and the United States of America (10·60 lb.), Germany (6·6 lb.), France (4·70 lb.), Austria-Hungary (2·17 lb.), and the United Kingdom (0·90 lb.). The consumption of coffee in Great Britain has, if anything, been curtailed, while that of tea has expanded to a remarkable extent. This is doubtless due to the purity and cheapness of tea when contrasted with the greater cost (per cup) and almost universal adulteration of coffee.

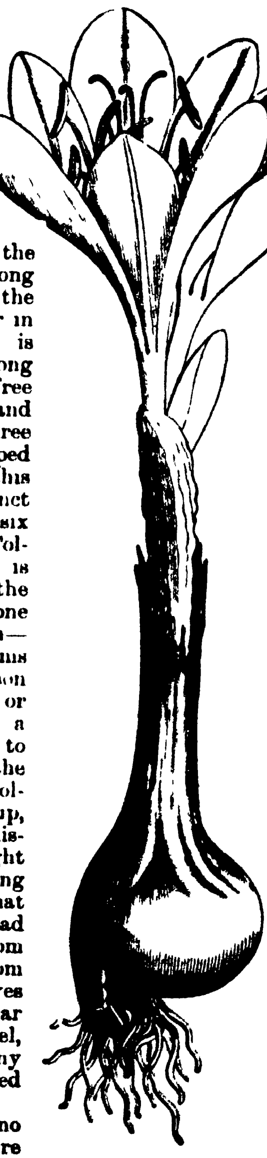
[G. W.]

Coke, T. W., afterwards Earl of Leicester (Coke of Holkham), one of the most famous agriculturists of the last quarter of the 18th and for nearly the first half of the 19th centuries, and probably the greatest agricultural improver of his times. Thomas William Coke was born in London in 1754, his father being Mr. Wenman Coke. According to a very interesting work recently issued, Coke of Norfolk and His Friends, by Mr. A. M. W. Stirling (*John Lane, London*), his early days were spent at Longford, Derbyshire, part of the family estate, Holkham, which was then in the possession of his great-aunt, Lady Leicester. Here it was that Coke acquired *that great love of farming and country sports which he displayed during the whole of his life. Although a great politician, elected for thirteen parliaments, covering a period of fifty-six years, his heart was always in the rural districts.* After his education had been completed by a short residence on the Continent, he entered into public life, being elected as member for Norfolk, as successor to his father, in 1776. Except for a short interval of retirement, he represented the county until 1832, when he finally retired. Coke, as stated by himself in a public speech, was twice offered a peerage during his first session in Parliament, and it is known that he had several subsequent offers, all of which he declined until 1837, when he accepted the title of Earl of Leicester, of Holkham, which had been bestowed upon his grandfather, but had lapsed through the lack of a male heir to that nobleman. In 1776 he became possessed of his estate, and was soon deeply engaged in farming land thrown on his hands. He studied agriculture in foreign countries, and adapted improved methods noticed in some of them to his land in England. By example and precept he induced his tenants to follow improved agriculture, encouraging them by the liberal covenants of the famous Holkham lease. It is stated by Mr. Prothero in The Pioneers and Progress of English Farming (Longmans & Co.) that when Coke took possession of his estate, not an acre of wheat was to be seen on the chiefly sandy soil from Holkham to Lynn, but only rye. No manure was purchased, and very little was made, a few sheep and half-starved cows being the only live stock. Coke marled his land, bought much manure, and kept a large number of live stock, introducing oilcake and other feedingstuffs to keep them He was determined to grow wheat, and was soon able to produce excellent crops of that cereal. It is stated that the rental of his Holkham estate rose from £2200 per annum in 1776, when he took it in hand, to £20,000 in 1816. Coke was a great improver of Devon cattle and Southdown sheep. In 1778 he introduced the famous Holkham sheep shearings, which soon became occasions for annual meetings of farmers and scientific men from all parts of Great Britain, some Continental countries, and America, to discuss agricultural topics. Open house was kept at Holkham for four days to a week when these meetings had become established. Coke's example in this respect was soon followed by the Duke of Bedford, Lord Egremont, and some other great landlords. The Earl of Leicester, as he had become, died in 1842.

[W. E. B.]

Colchicum, or **Meadow Saffron** (*Colchicum autumnale*), is a perennial plant with ground leaves, extremely common in light pastures in many parts of England, and there an agricultural nuisance. It belongs to a poisonous division of the nat. ord. Liliaceæ. From a small corm, about as large as a tulip bulb, buried

about 6 in. deep, and covered with a brittle brown skin, there rises in the early autumn a tuft of flowers having much the aspect of crocuses—flesh-coloured, white, or even variegated, with six nearly equal divisions, within which are found six stamens, whose anthers face out-



Meadow Saffron (*Colchicum autumnale*)

wards; within the bottom of a long tube, of which the Colchicum flower in part consists, is found an oblong ovary, perfectly free from the tube, and surmounted by three long, thread-shaped styles. By this free ovary, distinct styles, and six anthers, the Colchicum genus is known from the Crocus genus, one species of which—Saffron — blossoms at the same season in September or October. After a short exposure to sun and air, the flowers of the Colchicum wither up, and the plant disappears from sight till the succeeding spring At that time some broad leaves grow up from each corm, and from among those leaves rises a triangular oblong seed vessel, containing many whitish polished seeds.

There can be no doubt that cattle are injured by eating either the flowers or leaves of this plant, whose acrid flavour and heavy nauseous odour indicate its dangerous qualities. There is, however, little difficulty in destroying it, by hand-pulling the leaves when they first appear, and continuing to do so as they protrude above ground. Removing the flowers is useless. If the leaves are carefully destroyed for a whole season, many of the plants will appear no more; and those which show themselves in the succeeding spring will be so feeble as to perish finally after a repetition of the hand-pulling.

The corms are largely employed in the preparation of gout medicine, and are a source of some profit to those in whose fields they are allowed to remain; but they have little real value unless taken up as soon as the leaves turn yellow. If left in the ground till they flower, their medicinal value is much deteriorated. The seeds also are employed, and are far more efficacious than the corms. The peculiar poisonous principle called Colchicine—a substance very nearly the same as Veratrine—is prepared from both seeds and corms. [J. L.] [A. N. M'A.]

There are a good number of species of this genus, some of which are handsome garden plants, thriving in the open border under the same treatment as is suitable for daffodils Their leaves are much broader than those of the Crocus, and the flowers generally are larger. In addition to the various forms of *C. autumnale*, the following are cultivated in gardens: *C. montanum*, *C. Parkinsoni*, *C. speciosum*, and the most beautiful of all, *C. speciosum album*. [W. W.]

Cold. See CATARRH.

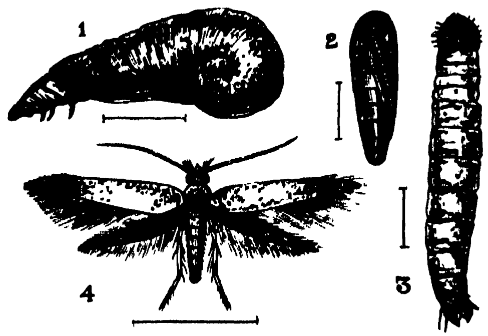
Cold-blooded Animals, those in which the temperature of the body varies in direct relation to that of the surrounding medium, whereas in warm-blooded animals the temperature of the body remains practically constant (exceptions being made for fevers, hibernation, and so forth) and independent of the temperature of the medium. Birds and Mammals are the only warm-blooded animals, they have a nervous mechanism by which the temperature of the body is regulated and kept constant. In a nestling, this regulating mechanism has not been established, in a hibernating hedgehog the regulating mechanism ceases to act when a certain external temperature is reached; both nestling and hedgehog are thus temporarily cold-blooded Reptiles, Amphibians, and Fishes are permanently cold-blooded We do not know much about the temperature of backboneless animals, but they all seem to be cold blooded. Three points must be emphasized. (1) the temperature of a cold-blooded animal is not necessarily the same as that outside, though it varies with it; (2) cold-blooded does not mean that the body temperature is necessarily very low; (3) the oldfashioned terms are therefore very unsuitable; they do not suggest what they are meant to suggest, hence in scientific discourse 'warm-blooded' animals are called *homoiothermal* and 'cold-blooded' animals *poikilothermal*. See ANIMAL HEAT, WARM-BLOODED ANIMALS. [J. A. T.]

Cold Storage. See REFRIGERATION and COLD STORAGE.

Cole, Colsa, or **Colza.** See BRASSICA and RAPE.

Coleophora anatipenella (the Pistol or Cherry Tree Case-bearer).—The curious dark-brown pistol-shaped case found on cherry leaves in summer is the 'house' of the larva of a small moth, about ½ in. in wing expanse, belonging to the Tineidæ, and known by the above

scientific name. Its wings are narrow and pointed, and densely fringed; the fore pair are creamy-white, with scattered fuscous scales, the posterior pair dusky. They fly in July and August, and lay their eggs on the leaves of cherry, sloe, and apple; the ova hatch in two to three weeks. In a few days a case commences to be formed over the larva, in which it passes its whole life, protruding its head and first few segments when feeding and crawling. The larvæ occur from August to June, and pass the winter on the trunk and boughs,



Cherry-tree Case-bearer (*Coleophora anatipenella*)

1, Larva in case 2, Larva free 3, Pupa 4, Adult.

firmly fixing the case to the bark by silk. They eat the buds in spring, and later the upper epidermis of the leaves, giving them a blotched appearance. Pupation takes place inside the 'case', and lasts three or more weeks. They may easily be destroyed by arsenical sprays. [F. V. T.]

Coleophora laricella (the Larch Coleophora), a small moth whose larvæ are frequently very harmful to larch trees. The moth has a wing expanse of ½ in., its wings are narrow and pointed, uniformly grey, the hind paler than the fore, both fringed with long pale hairs. The moths occur in June, and lay their eggs on the needles. In July small dusky-red larvæ come from them, which at once bore into the needles and tunnel them out for half their length, and the attacked ends shrivel up; the larva then cuts off the dead portion and forms a case, in which it lives. At first this case is dirty-white, but soon becomes brown. When young the larvæ leave their cases and tunnel freely into the needles, having fixed the case on by silk. In winter they spin the cases on to the axils of the twigs and on the stem, and hibernate in them. In spring they crawl up again and attack the young needles. Maturity is reached in May and June, the cases having been enlarged meanwhile by pieces of cut needles being added. Pupation takes place in the cigar-shaped cases. In spring the tips of the young needles are tunnelled, and turn brown in characteristic manner.

Prevention and remedial measures.—In isolated cases of attack, the trees should be cut and burnt in early May. In widespread attack, the lower branches may be lopped and burnt. Mixed plantations should be aimed at; suitable locality, soil, and open growth tend to lessen its ravages. [F. V. T.]

Coleophoridæ (Case-bearing Moths), a family of Tineid Moths, whose larvæ form cases of pieces of leaves or blossoms, in which they reside and pupate. See last two articles. [F. V. T.]

Coleus.—Popular garden plants; those with beautifully coloured foliage being the progeny of *C. Blumei*, a native of Java; others with handsome flowers being African. The best of the latter is *C. thyrsoideus*, a shrubby plant with erect racemes of gentian-blue flowers, produced in midwinter. They are all easily propagated from cuttings, and they grow quickly into shapely bushes. In winter they require warmhouse conditions, but during the summer they may be kept in a frame or even used as bedding plants. They all ripen seeds under cultivation, and from them new varieties may be obtained. [W. W.]

Colias edusa (Clouded Yellow Butterfly).—This beautiful butterfly some years appears in great numbers, especially in the south and south-east, and then is known to do some damage in its larval stage to clovers, lucerne, tares, and vetches. The butterfly occurs in September and October, a few in August; it is orange-yellow, with a broad black margin to the wings, and a black spot on each fore wing; orange lines run through the border of the front wings, and a narrow pink-and-orange border outside it, hind wings deeper orange, with a large, round, brighter spot, the male is 2 to 2½ in., the female 3 in., across the wings; the latter has several irregular yellow marks on the black border of the fore wings, also on the hind, and the posterior wings darker than in the male. The caterpillar is found in June and July; it is dark-green, with a white stripe spotted with yellow on each side, and reaches 1½ in. in length. The chrysalis is pale-green varied with yellow tints, black spots, and a stripe of dull dark-red beneath. Although not recorded as a pest, its great abundance at certain times makes it essential that our attention is drawn to its life-habits. [F. V. T.]

Colic, Gripes, or **Fret,** acute abdominal pain, commonly assignable to the bowels, but often simulated by disorders of the liver and other organs. Colic is conveniently considered under two heads, spasmodic and flatulent, while some authorities add a third, and name it worm colic. The first variety consists in violent cramps, or muscular contractions of the gut; the second of painful distension by reason of the elimination of great volumes of gas, which fails to pass by flatus from the rectum or by belching upwards. The presence of large numbers of worms gives rise to griping pains, giving a resemblance to one or other of the forms of colic already mentioned. The horse is the greatest subject of colic, and with him it is more serious than with other domesticated animals. He is more sensitive to abdominal pain, a more highly nervous animal, and has been known to die of pain and exhaustion, without the presence of serious complications,

which are considered under the title of BOWELS, DISEASES OF THE. Indigestion is the chief cause: the consumption of large quantities of indigestible food by gluttonous animals, or those which have been long fasted, or the drinking of deep draughts of cold water on a full stomach; sudden changes of diet, as from cooked foods, employed by dealers to make horses fat and round ('dealer's condition'), to the dry, hard corn, given to produce hard condition in hunters and working horses. Flatulent colic is more often the result of indiscreet feeding with green meat in the spring, or too many tares when the pods are ripening later in the season; clover wet with dew, or 'roots' too freely consumed. Besides these common errors inducing colic, there are less obvious causes, and of distinctly hereditary character, and not infrequently associated with a particular conformation known as 'washy', and implying a belly longer than normal between the last rib and the hip, and somewhat flat-sided, such defect being accompanied also by absence of depth in the chest. Animals of this conformation should not be bred from, for this and other reasons, as they are lacking in stamina and prone to colic.

The symptoms are those of acute pain, demonstrated by sudden loss of appetite if in the act of feeding, pawing with the front feet, striking at the belly with the hind ones, anxious countenance, sweating, groaning, rolling upon the ground, turning over on the back and throwing the head round in the direction of the flank, getting up again and repeating the same thing from time to time, with variable interludes, during which the remission of suffering is apt to deceive the attendant, who should not leave the animal although it may be seen to commence feeding. The symptoms of flatulent colic may be a little less pronounced, and the pain more continuous, with the distinguishing feature of distension of the flank, which feels like a drum when struck with the hand, and is indeed blown out by the gases in the large intestines, a condition which may extend to the stomach also, and even cause its rupture (see STOMACH).

Treatment.—When clearly spasmodic, and due to drinking well water or like causes, and the owner has no reason to associate the trouble with constipation or obstruction (see CONSTIPATION), diffusible stimulants and antispasmodics should be administered, as ½ to 1 oz. of chlorodyne, with 1 to 3 oz. of sweet spirit of nitre, or 1 oz. of aromatic spirit of ammonia (*sal volatile*), with 1 oz. of laudanum, or, in the absence of these medicines, ½ pt. of whisky in 1½ pt. of water may be given. Brandy, gin, old ale with ground ginger and pepper, are among the old farmhouse remedies available in emergency. Kneading the belly with the fists, and unloading the rectum with a greased hand and arm, and clysters of warm water with soap in it, may also be found beneficial. In the case of calves, lambs, and puppies suffering from colic, active massage can be practised with much benefit, the smaller animals lending themselves to such measures more readily than horses. The flatulent variety of colic, being so often accompanied or caused by obstruction of some kind, is best treated by laxatives, and the gases kept down by oleaginous draughts. Many experienced veterinary practitioners give an aloetic ball at first, while attempting to allay pain and reduce flatus by the administration of small doses of spirit of turpentine and linseed oil, ½ to 2 oz. of the former to 4 or 5 oz. of the latter. If the purging ball is not given, a larger quantity of oil may be administered. Puncture of the bowel with a fine trochar and canula is now practised with success, and, provided the instrument is sterilized, no great risk attaches to the operation, while immediate relief is afforded as the gas rushes through the tube, and the distension is visibly reduced. The so-called worm colic is nearly always caused by ascarides in the small bowel, and the turpentine dose before mentioned is well calculated to expel them, as is the aloetic ball. Food of a dry character should be withheld for a time, and the convalescent from colic should prove by his evacuations that a large soft bran mash has passed through the canal before being passed as fit for ordinary work.

[H. L.]

Collar. See HARNESS.

Colleges, Agricultural. See EDUCATION, AGRICULTURAL.

Collembola (Spring-tails).—A group of apterous insects, all of small size, the largest not more than ¼ in. They have a curious forked tail, bent under the abdomen, which enables them to proceed in a series of 'skips'. Several species feed upon vegetation to such an extent that they do considerable damage. They are mandibulate, and have short antennæ, and abdomen of six rings. The eyes are simple (ocelli), and arranged on each side of the head. See also art. APTERA. [F. V. T.]

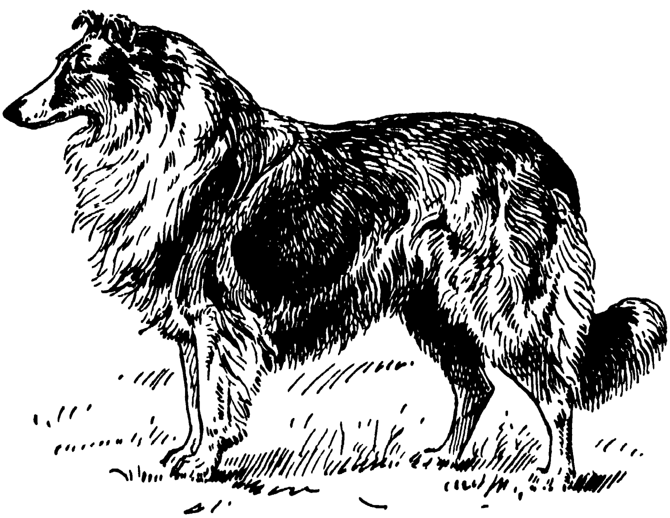
Collie, The.—The popularity of the Collie dog is not confined to any particular district of Great Britain, or to only one class of dog lover, as he possesses adherents on all sides, from the highest member of the aristocracy to the lowliest shepherd on the hillside. It is by no means an easy matter to attempt to trace the genealogy of the Collie, for though many theories on the subject have been propounded, there is very little that can definitely be accepted as evidence.

Suffice it therefore to be known that almost from time immemorial there has existed a race of dogs in Scotland whose peculiar forte it was to assist the shepherds in minding their flocks. From the earliest period these dogs appear to have been accepted almost generally as amongst the most intelligent members of the great canine family, so much so, in fact, that their intelligence, combined as it has been with a faculty for dealing tenderly with the sheep, almost precludes the possibility of their having sprung, at a comparatively recent period, from the wolf, though this is an idea that is entertained by many whose opinions are entitled to respect.

It is scarcely necessary, however, to devote much time to speculations as to the original sources from which the sheep dog or Collie originally sprung, especially as his origin must have been extremely remote. It is sufficient to know that, upwards of a hundred years ago,

the breed as it then existed bore the highest reputation for intelligence and docility. So much so, indeed, that evidence is forthcoming to show that, towards the commencement of last century, the then Duke of Richmond was not above crossing one of his famous Gordon setters with a black - and - white Collie bitch, the property of a well-known poacher, with the object of improving the intelligence of his dogs. This was a very high tribute to the merits of the Collie, and it may be added that the experiment of the duke proved so successful that descendants of the sheep-dog cross were to be found in the Gordon Castle strain for many years subsequently, in fact it is doubtful if it ever actually died out.

In the face of the evidence that is forthcoming to provide the excellent reasons which



Collie

prompted the Duke of Gordon to experiment with a Collie cross upon his setters, it is perhaps a little humiliating to the modern breeders to be compelled to refer to the motives which influenced a reversal of that policy by them a few years ago. At the time alluded to, the Collie had fallen upon rather evil days, for, to the great jeopardy of his future reputation as a sheep dog, he experienced the misfortune of being taken up by the aristocratic members of society as a fashionable breed. The result of this was that he was largely crossed with the Gordon setter, the object being to produce deep-coloured 'mahogany' tan markings, which the new patrons of the Collie preferred to the characteristic light shade of tan which distinguishes the true Collie.

The changes in colour and in the formation and carriage of the ears which were produced by this cross, were not, however, so dangerous to the future of the Collie as was the effect produced upon his coat, which in the case of the true sheep dog should be dense and weather-resisting, whereas that of the setter is longer, silkier, and more open. Upon the thickness of a Collie's jacket depends much of his ability to keep his body dry and warm on the hillsides during winter, and therefore had the evil example of his misguided but aristocratic patrons been imitated outside the towns, a vast amount of mischief would have been inflicted upon the breed.

The Collie, moreover, has been the victim of ill-advised experiments upon the part of some persons who breed dogs for exhibition purposes, as, in order to produce the additional length of head to which some modern judges attach importance, they have introduced a cross of the Borzoi into their kennels. As a consequence the intelligence of the Collie has been in some cases very much impaired, for the Borzoi is not by any means a brainy dog. On the other hand, the Collie is indebted to the breeders who raise dogs for exhibition for his increase in stature and a more profuse coat, though it can scarcely be suggested that the latter has in any degree improved his merits as a working dog, but rather the reverse.

The coat of a working Collie is undoubtedly one of the most important points about him, as unless his body is sufficiently protected from cold and damp, it is impossible for him to perform his duties on the hillside. The true jacket of the rough-coated Collie consists of an outer one of fair length and considerable thickness, whilst underneath it there should always be a second coat, which almost resembles a sealskin in texture and appearance. It is upon this coat that the principal duty of keeping the dog warm and dry is reposed, and as a consequence too much importance can scarcely be attached to the density of the Collie's underjacket.

The sheep dog being an animal that is called upon to do a good deal of work, it is essential that he should be an active dog; and certainly the build of a Collie conveys an impression of his possession of an almost unlimited capacity for undergoing hardships under trying circumstances. A lathily built dog, with no superfluous lumber about him, the Collie possesses speed enough to outpace any mountain sheep, speedy animals though the latter are, and his resourcefulness is displayed every hour of the day by the manner in which he meets unexpected difficulties as they arise. It is no uncommon sight to witness a Collie running over the backs of a number of sheep collected in the corner of a field, in order that he may reach the animal which his master has instructed him to separate from the rest of the flock. A good Collie, too, will never maul or injure his sheep, though his simulated rage may at times suggest to those who do not understand his disposition that he is a danger to his charges.

Such duties as a Collie is called upon to carry out, and especially the conditions of difficulty under which he very often has to work, necessitate the possession of a great deal of intelligence, and it may conscientiously be added that it is seldom that the Collie is found wanting in that respect. Possibly his close associations with his master may have developed his brain powers; but be this as it may, no observant human being who has studied the breed can have failed to be impressed by the singularly intelligent expression of the Collie's eyes. This characteristic of the variety is more apparent in the working than in the show dogs, but they all possess it; and so too, it may be added, do the poodle, the setter, and the spaniel, to a greater or lesser extent.

The sense of hearing is marvellously acute in this breed, the semi-erect ears of the true Collie apparently lending themselves by their shape to the conveyance of sound; whilst the peculiar swinging gait of the Collie, which to some degree resembles the skulking trot of his reputed ancestor the wolf, is a feature of the variety. To return to the question of coat, it may be observed that in the case of the rough-coated specimens it is far more luxuriant amongst the show dogs than it is amongst those who earn their living by hard work. In neither case, however, should the fringe of hair at the back of the legs, which is technically known as 'feather', extend down to the ground as in the setter. If this formation appears, a cross of the latter is to be strongly suspected, and with it there will be a reduction in the density and weather-resisting capacity of the coat, which is a serious fault in a Collie.

A good Collie, like a good horse, cannot be a bad colour, but when a tan shade of jacket is present it ought always to be of a light hue; for if it shows a dark or mahogany tinge it is practically certain that the dog possesses a Gordon setter cross. All black, all white, black and white, black tan and white, sable, sable and white, and 'merle', which is a peculiar blue mottled shade, and usually associated with a 'wall' or 'china' eye, are permissible in the Collie, the sable and white, and the black, white, and tan being the most popular. For working purposes, the large-sized dogs are not so much in demand as the middle-weights, for they are not considered to be so active; but for exhibition purposes the heavier and more imposing-looking ones are preferred.

The smooth-coated Collie differs in no respect from the rough-coated variety, excepting that the outer jacket is very little longer than the sealskin-like underneath one. Being shorter, it naturally feels somewhat harsher to the touch, but the coats of no Collie should be soft or silky, as, if they are so, it is impossible that they can resist the weather.

So far as looks are concerned, it is a somewhat peculiar fact that a really handsome smooth-coated dog is far more difficult to find than an equally good-looking bitch, the reason of this being impossible to account for. The intelligence of either variety is perfectly equal, though for utility purposes many shepherds prefer the smooth, as their coats are not so liable to become clogged with mud or snow when the weather is bad. [V. S.]

Collier, a name given to the Bean Aphis on account of its black colour. See APHIDES.

Collings, Charles and Robert.—These brothers, of whom the younger is usually named first, as the more notable, were among the most famous of the early improvers of the Shorthorn breed of cattle. Robert was born in 1749, and died in 1820; while Charles was born a year later, and lived until 1836. They have sometimes been called the founders of the breed; but that is an error. It is not too much to say, however, that they led the way to the raising of the Teeswater or Durham cattle, a local breed, into the Shorthorn of national and ultimately world-wide celebrity. Although they bought the animals from which they established their herds from other breeders, they improved the type wonderfully, refining it in a marked degree. The fame of their improvement was enhanced by the expedient of sending specimens of their cattle about the country in a van for exhibition, and it became fully established at their sales at Ketton, in Rutland, and Barmston, in Yorkshire. At Ketton, in 1810, Charles Collings's bull, Comet, made the price of 1000 guineas, unprecedented and astonishing at the time. So generally recognized was the improvement effected by the brothers, that the type of Shorthorn which they established ousted the older and coarser type completely from the favour of breeders. [W. E. B.]

Colloid is the technical term applied to a non-crystalline and non-diffusible body, having a jelly-like character. A good illustration of the characteristic properties of colloids is shown in the method adopted for separating crystalloids from colloids. The liquid containing the two classes of substance in solution is placed in a bladder of animal membrane or parchment, and then immersed in running water; the crystalloid will diffuse through the bladder and be carried away in the running water, whilst the colloid, being non-diffusible, remains behind in the bladder. Silica jelly is a colloidal substance, and in its preparation it is purified from common salt, &c., by the above process. Proteid substances are typical colloids, also many iron and other salts have colloidal properties. [R. A. B.]

Colon.—The colon is the name given to a part of the large intestine. In the horse this portion is divided into the double or large colon, and the small or floating colon. The first portion is termed double because when taken out of the abdomen it is arranged in the form of two parallel portions; but in order that it may be accommodated within the cavity it has again to be doubled, so that in its natural disposition it presents four portions, which have distinct names. In an animal of medium size its length is about 10 ft., and its capacity about 16 gal. It is puckered on its outer surface, due to the arrangement of its longitudinal muscular fibres, which are not uniformly distributed, as they are in the small intestine, but collected into bands, which shorten the bowel by throwing it into folds. The small or floating colon

succeeds the double colon. It is much narrower than that bowel; indeed, in calibre it does not greatly exceed the small intestine, from which, however, its coils are readily distinguished by their puckered appearance. In a medium-sized animal it is about 10 ft. in length. Constipation or impaction of the double colon is a frequent occurrence in the horse, and it is chiefly in this position that concretions, calculi, and the various varieties of dust balls are encountered.

[J. R. M'C.]

Colorado Beetle (*Doryphora* or *Chrysomela decemlineata*), an American species of beetle which has proved very destructive to the potato crop over a large area of the United States. See DORYPHORA DECEMLINEATA.

Colostrum.—Colostrum, or 'beestings', is the name given to the secretions of the udder about the time of parturition. It includes all these secretions, from the first drops of brownish viscous liquid and the non-viscous yellow liquid which begins to form some time before calving, to the time when normal milk is formed some days after calving. The typical colostrum proper is formed from a day or two before calving to some three or four days after. This liquid has a yellow colour, sometimes reddish, due to the presence of blood. Under the microscope typical forms are seen, among which are the so-called colostrum corpuscles, grape-shaped bodies four or five times the size of ordinary milk-fat globules, and very like white blood corpuscles, arranged in clusters like bunches of grapes; these do not disappear entirely from the milk for a week or two after calving.

The colostrum has a rather pungent taste of a salty nature, and also a peculiar smell. It exercises a purgative action in the intestines of the calf, a natural medicinal property which renders it very suitable for removing the materials accumulated in the intestines before birth. The composition renders it a very suitable food at this stage. It is, however, very unsuitable for cheese and butter making, being very liable to early putrefactive decomposition. It coagulates very slowly with rennet, and does not give a normal curd. It will, however, coagulate with heat, acetic acid, and mercuric chloride. It should only be used for cheese and butter making when it has so nearly approached the composition of normal milk as to give the usual thin scum on the surface when a small quantity is heated to 163° F. or higher and no longer shows any signs of coagulating. The specific gravity of colostrum is from 1·046 to 1·047, and averages 1·068 at 15° C.

Eugling gives the following as the average composition of the colostrum of twenty-two cows:—

		Per cent.
Water		71·69
Total solids...		28·31
Fat	3·37	
Casein	4·83	
Albumin	15·85	
Sugar	2·48	
Ash	1·78	
		100·00

The high percentage of total solids consisting of such a high proportion of albumin is most characteristic, and explains why the colostrum coagulates on boiling. The fat differs from that of milk in having a high melting-point (40° to 44° C.). The volatile fatty acids are also low (Reichert-Wollny figure about 6, soon after calving). The sugar consists largely of sugars other than milk sugar, among which dextrose is the chief. The ash contains a high proportion of calcium phosphate and other salts.

[J. Go.]

Colour in Animals.—As a rule the colour of animals is due to the presence of pigments which absorb some of the rays of light and reflect others. This is possible because white light, as a rainbow indicates, consists of rays of different colours, viz. red, orange, yellow, green, blue, indigo, and violet. The difference in the colour of the rays depends on the difference of the rapidity of the vibrations producing them, the red rays being the least rapid, the violet the most rapid. According to one theory there are three primary colours, green, red, and violet; according to another there are six primary colours, viz. three pairs of antagonistic colours, black and white, red and green, yellow and blue. It is supposed that we recognize colours because there are certain elements in the retina of the eye which answer to the primary colours, the intermediate shades being produced when the primary colour terminals are stimulated in different degrees.

Though colour is, as a rule, due to the presence of pigments, a white colour, though sometimes due to a pigment (as in fish and insects), is generally due to the light being scattered by minute bubbles of air, while metallic tints are produced by excessively fine striæ—in the case of birds, however, without a background of pigment, the fine grooves on the surface of the feathers produce no more effect than the pattern which runs through a white tablecover.

When all the visible rays of light are absorbed an object appears black, when all the rays are reflected it appears white, when they all pass through without being decomposed the object appears transparent; but when by means of a prism a ray of light is decomposed, all the colours from red to violet become visible.

In melanin, hæmoglobin, and chlorophyll we have familiar examples of pigments. The skin of a negro appears black because it contains sufficient melanin to absorb all the rays of light; blood appears red because its colouring matter hæmoglobin reflects the red rays and absorbs the others. Plants are green because they contain chlorophyll, which reflects the green rays and absorbs the others.

Frequently several pigments exist in the same structure, *e.g.* black, brown, and yellow pigments may occur in the same hair. When this happens, all the pigments may take part in producing the colour, or they may be so distributed that only one is conspicuous. As in wild forms the colour is remarkably constant, and often varies with the environment, it may be assumed that the surface colours of most animals serve some useful purpose, and have been acquired and maintained by natural selection.

Usually there is some obvious relation between the colour of animals and their surroundings, *e.g.* white prevails in Arctic animals, yellow in desert species, green in birds which frequent evergreen forests, while nocturnal animals are so coloured that they are inconspicuous in the twilight.

Except for special reasons, most animals are protectively coloured. When, instead of being inconspicuous in their normal habitat, they are out of harmony with their surroundings, there is usually some more or less obvious reason. In some cases a conspicuous coloration seems to enable animals more readily to obtain their food, or be recognized by their friends, or it may make them more attractive during the breeding season, or serve as an advertisement of inedibility. In the case of animals living under domestication, colour sometimes plays an important part. Red and black specimens of Chillingham, Chartley, and other park cattle are of little value. On the other hand, some years ago many breeders were greatly perturbed when a white calf appeared in a Shorthorn herd, and roans were considered undesirable; now, however, white and roan Shorthorns are often amongst the prizewinners. When, as sometimes happens, too much attention is directed to, say, the colour of cattle, there is a danger of the make and the milk record suffering; and when, in order to maintain a fashionable colour, inbreeding is resorted to, the courage, vigour, size, and fertility may be gradually but effectively diminished.

Black and White Colours.—As already said, black is due to all the rays of light being absorbed by the pigment melanin, while white, though sometimes due to a pigment, is, as a rule, due to all the rays of light being scattered by minute bubbles of gas. Melanin may occur in the skin only, or in the hair and feathers as well as the skin, it may be the only pigment present, or it may be accompanied in the same hair and the same feather by other pigments. Black is the normal colour of various wild animals, and many animals, tame as well as wild, now and again produce black or melanic individuals. Black varieties seem to be most common in low-lying damp areas — perhaps because they are better able than light varieties to survive in a moist climate. As dark colours readily absorb radiant heat, while light colours absorb heat with difficulty, it is generally said that a black skin and a light coat of hair (or feathers) are the best combination for a hot country.

Light-grey horses with a dark skin do better in the Tropics than black horses; but for some reason grey horses seem to be less fleet than black and brown horses. Grey thoroughbreds, once fairly common, are now rare; they seem to have been eliminated for lack of speed. In like manner, black American trotters are more common than grey trotters, and the record is better for black than for grey trotters by 9 or 10 seconds per mile.

Given one or more black individuals, it is possible by working on Mendelian lines to rapidly establish a black breed. A black breed, whether formed slowly or rapidly, generally breeds true, and proves prepotent over light breeds. During recent years, various black strains of Shetland ponies have been formed. When a black stallion, the offspring of black parents, is mated with bay, dun, grey, and other light-coloured Shetland mares, the offspring are usually black (*i.e.* black is dominant, the lighter colours are recessive), and the crosses when interbred produce a number (about 25 per cent) of black individuals which breed true. In a like manner Galloway and other black cattle are dominant over red, yellow, and white Highland cattle; but crosses between black and grey rabbits are grey, while crosses between black and splashed white breeds of fowls are blue.

There is no evidence that any of the wild species from which horses have sprung were black, hence in all probability the black breeds of horses now in existence were formed under domestication. They may have originated from black (melanic) sports, or have resulted from crossing. I have obtained bays by crossing yellow duns, and a bay with a yellow dun sometimes yields a pure black. In some cases the male is black and the female a grey or neutral tint; *e.g.* in *Lyrurus tetrix* (the Black Grouse) the male, with the exception of the under tail-coverts, is black, while the female is mostly rufous and buff. That the female is protectively coloured is suggested by the fact that the male, when barely able to fly, during the moulting season temporarily assumes the colour of the female.

When pigment is completely absent from the hair or feathers, but present in the skin and in the eyes, we have a white animal. When absent from the skin and from the eyes, as well as the hair and feathers, we have an albino. In an albino bird, *e.g.* a peacock, the metallic tints (due to excessively fine striae upon the surface of the feathers) are lost, as well as the tints due to pigments. This is owing to the fact that colours in birds due to peculiarities of structure are only produced when there is a background of dark pigment.

In many cases white varieties are recessive to black. Albino and white varieties of mice, rats, rabbits, and fowls usually produce coloured offspring when crossed with black varieties. But when the white parent belongs to a prepotent strain, the offspring may be white from the outset or eventually become white, or from first to last be a blend of black and white. The Percheron breed of horses has long consisted mainly of grey individuals. Perhaps because greys until recently were preferred to blacks, browns, and bays, greys are still prepotent over black, grey dams being more prepotent than black dams, and grey sires than black sires. Sometimes a crossbred light-coloured stallion is prepotent over a purebred black mare. For example, a white-dun pony out of a dappled-dun mare (the offspring of a bay mare and a white stallion) recently proved prepotent over dark-brown, bay, and chestnut mares. It hence follows that if for any reason a light-coloured horse happens to be highly prepotent, he may get offspring like himself out of dark-coloured mares, even if they belong to pure strains.

When white markings—e.g. a blaze, or 'white stockings', white spots, or a wall-eye—appear in a breed they are usually extremely persistent. The ass usually produces whole-coloured mules, nevertheless mules out of piebald and spotted mares are sometimes piebald or spotted. Again, the offspring of bald-faced, wall-eyed Clydesdales generally have a blaze and at least one wall-eye.

Crosses between white and coloured individuals are sometimes nearly intermediate in colour. This happens when both strains are about equally prepotent. In the blue-grey Galloway-Shorthorn crosses we have an instance of what happens when nearly equally prepotent black and white races are blended, while in roan-coloured Shorthorns we have a nearly equal blend of a white and a red breed. When white and black breeds or strains of horses are crossed, the foals are often black at birth, later they are of an iron-grey colour, and eventually they may be white. White and bay and white and chestnut frequently yield red-roans, but like white and yellow dun they may give a white dun.

It is interesting to note that when two white strains of the same breed are crossed there is often reversion. For example, when West Highland white terriers from different kennels and with a different history are crossed, the majority of the offspring may be coloured—consist mostly of yellow, red, and black individuals.

In mammals the coat is usually lighter in winter than in summer, in warm as well as in cold areas. In some cases the change of colour serves to make them less conspicuous to their enemies, in others it gives them a better chance of approaching their prey, while in all cases it may prevent the loss of heat. Examples of animals that become white in winter are the Arctic fox, Alpine hare, stoat, ermine, and ptarmigan.

Brown, Bay, and Chestnut.—These colours are usually due to the presence of red, black, and yellow pigments in the cortex or outer layer of the hair—the medulla or axis of the hair, as in white individuals, contains air. When black prevails the colour is dark-brown, when red prevails the colour is bright-bay, when the black is limited or inconspicuous the colour may be chestnut, when the yellow prevails the colour may be yellow-dun or foxy-red. It is difficult to say how the bays and browns of domesticated animals were originally acquired. They may have arisen spontaneously, just as black and red varieties of wild animals now and again suddenly make their appearance, or they may have resulted from intercrossing. Darwin arrived at the conclusion that horses had descended from 'a dun-coloured more or less striped primitive stock'. This view is supported by the wild horse recently discovered in Mongolia being of a dun colour, by asses and zebras being invariably some shade of dun; by the piece of skin discovered in Patagonia, and believed to belong to the extinct horse Onohippidium, being of a dun colour; and by hybrids being frequently dun-coloured and more or less striped.

If the wild ancestors of the horses were some shade of dun, the question arises, how were bays, browns, &c., derived from a dun stock? As most duns have black and red as well as yellow pigment, a bay may be regarded as an unusually dark-yellow dun, and there is no hard-and-fast line between bays and browns, or between browns and blacks.

Professor Ridgeway believes that by the blending in varying degrees of a bay horse evolved in North Africa with white and dun horses of Europe and Asia, the various shades of grey, rufous-grey, roan, skewbalds, piebalds, chestnut, brown, and black were eventually produced.[1] There is, however, no evidence that wild horses of a bay colour occurred in prehistoric times in North Africa.

The offspring of two yellow duns are usually dun, but now and again they are chestnut or bay. When a bay is crossed with a yellow dun a black is sometimes obtained, which, crossed with a yellow dun, may give a brown. These results indicate that by the crossing of duns belonging to different varieties or species, bays and browns as well as blacks would probably appear soon after horses and other mammals were domesticated. It is also possible that bays and browns may have suddenly appeared as sports, in wild as well as in domestic animals. It is sometimes a matter of some importance to maintain a bay or a brown colour, or convert a grey herd into a black one. To be in a position to maintain or alter the colour of a herd it is necessary to know which colours are most prepotent. By making use of the records contained in Weatherby's General Stud Book of Race Horses, it has been ascertained by Mr. C. C. Hurst that bay and brown are more prepotent than chestnut, or, to use the Mendelian phraseology, bay and brown 'are dominants to chestnut, which is recessive'.

In support of this view Mr. Hurst points out that St. Simon, Ladas, Merry Hampton, and other sires of a bay or brown colour, descended from bay or brown parents, have invariably produced with chestnut mares belonging to chestnut strains, bay or brown offspring. When, however, one of the parents of bay and brown sires is a chestnut, half the foals out of chestnut mares are chestnut, and half bay or brown. Chestnuts bred in this way with rare exceptions breed true, i.e. produce chestnut offspring only. It thus appears that there are bays and browns which with chestnuts produce no chestnut offspring, and bays and browns which with chestnuts yield on an average 50 per cent chestnut and 50 per cent bay or brown offspring—the first are pure bays and browns, the second crosses which had either a chestnut parent or grandparent. [J. C. E.]

Colour in Plants.—The colouring matter in the leaves, flowers, fruits, and other parts of plants is associated either (1) with small specialized protoplasmic structures (plastids) in the cells, or (2) dissolved in the cell sap. The most important and most widely distributed of all such colouring substances is *chlorophyll*, the

[1] Origin and Influence of the Thoroughbred Horse, p. 423.

green material to which the colour of the majority of plants is due. It is met with in the *chloroplastids*, which are present in great numbers embedded in the colourless protoplasm of the cells of leaves, stems, and other parts of plants exposed to light. Chloroplastids are also found in the purple leaves of certain varieties of cabbage, beetroot, 'copper' beech, Coleus, &c., but their presence is masked by the purple-coloured cell sap which these plants contain. The formation of chlorophyll is usually dependent upon the access of light, but in certain ferns and the seedlings of some conifers it is produced even when the plants are kept in the dark. An adequate temperature is necessary for its development, as is also the presence of iron and phosphates in the soil. For its relationship to assimilation see vol. i, p. 226. Chlorophyll permeates the chloroplastids as an oily solution, which is not extracted by water, but readily dissolved by ether or alcohol. It is an exceedingly unstable substance, and it is doubtful if it can be extracted from the tissues of plants without undergoing some chemical change. The alcoholic extract from leaves exhibits a peculiar red fluorescence, appearing blood-red in reflected light, and bright-green by transmitted light. The colouring matter is easily decomposed, and changes rapidly to a dirty-brown tint, especially when exposed to light and air. Weak acids change it to a brown substance, *chlorophyllan*, while stronger acids decompose it with the formation of an amorphous compound, *phylloxanthin*, and crystalline *phyllocyanin*, both of which exhibit red fluorescence in ethereal solutions. Weak alkalis have little effect on the colour or fluorescent property of chlorophyll. A small amount of sodium carbonate added to water in which green vegetables are to be boiled, tends to preserve the fresh colour of the latter.

In the parenchyma of the root of a carrot the plastids are colourless but contain peculiar orange-yellow crystals of *carotin*, to whose presence the characteristic colour of the carrot root is due. Carotin is found also in the chromoplastids of the petals of many yellow flowers, and also in the chloroplastids of green leaves. It appears to be one of the most widely distributed colouring substances in plants. It is insoluble in water, very slightly soluble in alcohol or ether; but it dissolves readily in chloroform carbon bisulphide, and gives to these liquids a deep blood-red colour. In the yellow petals of many flowers are chromoplastids, which contain another yellow oily substance, *xanthin*: it is soluble in alcohol. The scarlet petals of the poppy possess yellow chromoplastids along with a red cell sap. In the scarlet fruits of tomatoes, strawberries, roses, mountain ash, and other plants are found chromoplastids which have been derived from ordinary green chloroplastids. The orange-red pigment in them appears to be carotin, which is produced directly by the plastids, but part of the colouring material may be derived from the chlorophyll originally present. In the leaves of Box, and in Thuja and other conifers, the chloroplastids sometimes gradually change to a reddish or yellowish brown in winter, and resume their normal green tint in spring—a change which is largely due to the cessation of chlorophyll production at low temperatures, and a destruction of it by light. During the fading vitality of the leaves of trees and shrubs, straw of cereals, and other parts of plants in late summer and autumn, the chloroplastids change in form and colour, and ultimately become disorganized. In their place is found many minute deep-yellow or orange granules, which remain in the cell for some time after the remaining contents have been transferred to seeds, fruits, buds, and other storage centres in the plants. The yellow colouring material is sometimes spoken of as xanthophyll: it is sometimes considered to be a form of carotin, but its nature is very imperfectly understood.

These pigments are all associated with the plastids of the cell; there are, however, certain pigments which are found dissolved in the cell sap. One of these is *anthocyanin*, which gives a violet-blue or pink colour to the petals of many flowers, to grapes and other fruits, and to various parts of plants, such as the leaves of purple cabbage, the underground parts of beetroot, and the stems of a great variety of plants. This pigment, which is soluble in water, is reddened by acids, and changed to a bluish or violet tint when acted on by weak alkalis. Possibly several slightly different modifications of anthocyanin occur in plant tissues. They all appear to be closely related to tannins and glucosides, and their formation is in some way influenced by the presence of sugar in the cells. Low temperature encourages the production of anthocyanin, hence it is generally present in alpine plants, and often increases in quantity in the fading leaves of trees in autumn and winter. In some plants a soluble yellow pigment—*anthochlorin*—is seen in the cell sap, but little is known of its chemical nature. [J. P.]

Coltsfoot (*Tussilago Farfara*).—This is a most troublesome weed of the order Compositæ, akin to the common groundsel. Its stem grows horizontally and extensively at considerable depths underground, often 2 or 3 ft. below the surface. This underground stem is remarkably tenacious of life, so that if even a small portion of it is left in the ground, the plant soon reappears. On this account Coltsfoot is extirpated with very great difficulty. In March or April, scaly shoots from 4 to 6 in. high appear above-ground, and each of these ends in a single head of yellow flowers.

There are special shoots whose sole business is flower making and reproduction. Certain flowers of the head can make a seedlike fruit, which is crowned with a tuft of white hair in order that the wind may readily waft it away and freely disseminate the plant. After flowering, the green leaves emerge from the ground. They are thick and large, in shape and size like the sole of a colt's foot, and the whole lower surface is densely covered over with white cottony hairs. This weed infests wet sands resting on impervious clays.

For extirpation, the following methods may be adopted: (1) Prevent seeding. It is a mistake to omit this precaution. In dealing with

Coltsfoot, we must never forget that the flowers appear before the leaves. (2) *Starve out by removing the green leaves as soon as they appear.*

Coltsfoot (*Tussilago Farfara*)

1, Disk floret. 2, Ray floret 3, Fruit

(3) Drain the land, and pull out as much of the plant as possible as soon as the flowering shoots are seen. [A. N. M'A.]

Columbine. See AQUILEGIA.

Colutea, a laburnum-like shrub with pinnate leaves, clusters of yellow flowers, and curiously inflated pods containing beanlike seeds, from which the plant gets its popular name of bladder senna. Although a native of South Europe it is quite hardy in the British Islands, and in the warmer parts has become naturalized, being common on railway banks near London. In Germany it is employed as a fence plant in the same way as we employ privet. [W. W.]

Colza. See RAPE.

Combustion. — When chemical action is accompanied by the evolution of heat and light, the phenomenon is called combustion. The burning of a piece of wood in air is a good illustration of what is meant by combustion; in this instance the constituents of the wood are uniting chemically with a constituent of the atmosphere, namely oxygen, and in so doing so much heat is produced that light is emitted, in other words the wood burns. When the amount of heat produced is feeble, the combustion is said to be slow or incipient; whilst when it is considerable, the combustion is said to be rapid.

For convenience, one of the substances taking part in the chemical change is said to be combustible, whilst the other is said to support combustion; usually the substance which surrounds or envelops the other is said to be the supporter of combustion, though this distinction does not in every case hold. The oxygen in the atmosphere is the most general supporter of combustion, and the terms 'combustible' or 'incombustible' are applied to substances which either burn or do not burn in air. During the process of combustion, heat is always given out. Different substances give out different amounts of heat, according to their chemical composition, thus 1 lb. of fat will on burning give out two and a half times as much heat as 1 lb. of starch. The heat given out by a definite weight of a substance is called the heat of combustion of that substance.

Before a substance will combust or burn in air, it is necessary to heat it up to a certain temperature. The temperature at which a substance takes fire or ignites is called the ignition-point. The ignition-point varies in different substances; a few will ignite at the ordinary temperature without the addition of heat; such substances are said to be spontaneously inflammable, and must necessarily be preserved out of contact of air. The structure of the Davy lamp well illustrates the meaning of the ignition-point of a substance. The rusting of iron illustrates slow combustion, whilst the burning of a match illustrates quick or rapid combustion. [R. A. B.]

Comfrey (*Symphytum*) — A genus of perennial plants belonging to the nat. ord. Boraginaceæ, remarkable for the excessive roughness of the

Prickly Comfrey (*Symphytum asperrimum*)

leaves; such plants cannot be expected to yield good forage. Two species are common British weeds; another Prickly Comfrey (*S. asperrimum*), in spite of its roughness, has been introduced

from the Caucasus on account of its productiveness, and tried on poor moorlands where clovers will not grow. It now grows plentifully beside streams, and used to be boiled and eaten by cottagers. It grows with underground suckers, is easily propagated by division, pushes early in spring, and is extraordinarily productive, so that it soon gets complete possession of the land. Once in possession, eradication is not easy. Although this Comfrey has been tried both for 'green manuring' and as a forage crop, it has met with but little favour for either purpose. It requires a rich well-manured soil, and does not flourish on land that would be most benefited by green manuring. As a forage crop for supplying successive cuts of green food for dairy cows it was much advocated in the past. From 40 to 50 tons in six cuttings can be got after the first year in favourable situations. But its coarse and watery nature renders it altogether inferior to other crops grown for this purpose. It is allowed to become partially withered by standing for about eight hours before being fed. When dried it may be mixed with straw instead of hay for chaff-cutting. Its deeply rooting habit enables it to resist drought to a greater degree than most green soiling plants. It is usually propagated by sets or cuttings planted 3 ft apart on drills of the same width, 4840 sets being thus required to plant an acre. [A. N. M'A.]

Commons and Rights of Common. — Common, as a legal term, has been defined as a right or privilege which one or more persons claim to take or use in some portion of that which another man's lands, waters, woods, &c., do naturally produce, without having an absolute property in such lands, waters, woods, &c. (Tomlin's Law Dictionary). In ordinary parlance the word 'common' is used of the land over which the right is exercised

1. DIFFERENT KINDS OF COMMON.—There are four principal kinds of common: (*a*) common of pasture; (*b*) common of piscary or fishing; (*c*) common of estovers, or the right of cutting wood on the land of another, (*d*) common of turbary, or the right of digging turves in the soil of another There may also be a right of common to get stone and sand out of the lord's waste (Heath *v.* Deane, 1905, 2 Ch. 86, 74 L. J. Ch. 466).

(*a*) Common of *pasture* is the right of feeding one's beast on another's land. It is usually exercised on land formerly waste of the manor, the soil of which belongs to the lord of the manor. If exercised over arable land after harvest until the land be sowed again, in cases where the lands of several persons lie intermixed in many small parcels it is commonly called 'common of shack' (see Sir Miles Corbet's case, 1585, 7 Co. Rep. 5*a*). Common of pasture *appendant* is annexed to arable land by the original grant from the lord of the manor, and extends over the waste of the manor, but can only be claimed for such cattle as are *levant* and *couchant* on the land, that is to say, as many as the land will keep during the winter (Tyringham's Case, 1584, 4 Co. Rep. 36*a*). It can be claimed by prescription only, as no grant of such a right is possible since the statute of *Quia Emptores* (18 Edw. I, c. 1). Common of pasture *appurtenant* may be annexed to any land, and is not confined to such beasts as are usually termed commonable, as horses, oxen, cows, and sheep, but may extend to swine, goats, and geese (Co. Litt. 122*a*). It may be claimed by grant or by prescription, and in respect of any kind of land. Under the Prescription Act, 1832 (2 & 3 Will. IV, c. 71), no right of common shall be defeated if enjoyed for thirty years without interruption by showing only that such right was first enjoyed at any time prior to such period of thirty years, and if enjoyed for sixty years the right is to be deemed absolute and indefeasible. The claim must be in respect of a certain number of cattle, or if for an uncertain number it must be limited to those *levant* and *couchant* on the land to which it is annexed (Anise's Digest). A claim without restriction as to number of cattle is bad (Benson *v.* Chester, 1799, 8 T. R. 396) The right cannot be claimed by custom except by copyholders of a manor.

Common *in gross* is a liberty to have common alone without any lands or tenements in another's land. It is annexed to a man's person by grant to him and his heirs by deed, or it may be claimed by prescription. Common *per cause de vicinage* or by reason of neighbourhood arises by prescription where two commons adjoin each other, and the persons having a right of pasturage only over one of the commons allow their cattle indiscriminately to range over both (Co Litt 122*a*). It need not necessarily exist between persons having rights of common property so-called, but, as it seems, may be between two proprietors of neighbouring lands, though there be no other right of common over the lands on either side (Jones *v.* Robin, 1847, 10 Q. B. 620, 17 L. J. Q B. 121).

(*b*) Common of *piscary* is a fishing in waters on the soil of another person, and may be either appendant, appurtenant, or in gross Common of fishery does not exclude the right of fishing of the owner of the soil, but a right to a several fishery does (Co. Litt. 122*a*) It may be claimed by copyhold tenants of a manor by custom (Tilbury *v* Silva, 1890, 45 Ch. D 115), but not by inhabitants of a parish (Bland *v.* Lipscombe, 1854, 24 L. J. Q. B 155).

(*c*) Common of *estovers* is the right of cutting wood for repairs and fuel, and it can only be claimed by prescription in respect of an ancient house. The right will not be lost by the pulling down of the house, if another one be rebuilt.

(*d*) Common of *turbary* may be appendant or appurtenant to a house, but cannot be appendant to land without a house (Tyringham's Case, 1584, 4 Co Rep 36*a*).

2 INCIDENTS OF RIGHTS OF COMMON —The ownership of the soil of the common being in the lord, he may exercise all rights of ownership which do not injure the rights of the commoners (Robertson *v.* Hartopp, 1889, 43 Ch. D. 484, 59 L. J. Ch. 553). He may thus plant trees, make fishponds, dig clay and minerals, and sport. By the statutes of Merton (20 Hen. III, c. 4) and 2nd Westminster (13 Edw. I, st. 1, c. 46), the lord of a manor may approve or inclose part of

the common against the commoners, provided that he leave sufficient pasture for them. The Law of Commons Amendment Act, 1893 (56 & 57 Vic. c. 57), makes the consent of the Board of Agriculture necessary to any approvement or inclosure under those statutes. These statutes only apply to common of pasture. A commoner may bring an action against the lord, a commoner, or a stranger for disturbance of his rights of common, and in some cases may himself abate that which prevents his enjoyment of his commonable rights, as in Arlett *v.* Ellis (1827, 7 B. & C. 346), when it was held that the commoner might break down a fence put up by the lord which was inconsistent with his rights. The public as such (except in some cases by statute) have no right to use common lands for recreation or exercise, but a custom for all the inhabitants of a parish to play lawful games on a common is legal (Fitch *v.* Rawling, 1795, 2 H. Bl. 393).

3. EXTINGUISHMENT OF RIGHTS OF COMMON.—Rights of common may be extinguished in various ways, as by release, unity of possession of the land, enfranchisement of a copyhold, or inclosure. But an enfranchisement of copyhold land taking place under the Copyhold Act, 1894 (57 & 58 Vic. c. 46), does not deprive the tenant of any commonable right to which he is entitled in respect of the land enfranchised. A large number of commons have been inclosed under local Acts of Parliament. The Inclosure Act, 1845 (8 & 9 Vic. c. 118), provided for the appointment of commissioners to facilitate the inclosure and improvement of common lands, but provided that lands within certain distances of large towns were not to be inclosed without direction of Parliament. The powers under this Act, which has been amended by several later statutes, are now exercised by the Board of Agriculture and Fisheries. The Metropolitan Commons Acts, 1866, 1869, and 1878 (29 & 30 Vic. c. 122; 32 & 33 Vic. c. 107; 41 & 42 Vic. c. 71), form a code for the regulation and preservation as open spaces of Metropolitan commons situate within the Metropolitan police district, and schemes for that purpose may under these Acts be settled and confirmed by Parliament after local enquiry. The Commons Act, 1876 (39 & 40 Vic. c. 56), deals with the regulation and improvement of commons outside the Metropolitan area, and enables orders to be made by the Board of Agriculture and Fisheries for that purpose after local enquiry, with the consent of two-thirds in value of the legal interests in the common and the lord of the manor (if any). See INCLOSURE ACTS. [A. J. S.]

Comparative Anatomy.—OSTEOLOGY.—The skeleton is popularly taken to denote only the bones, a system of hard parts forming a framework which supports or protects the softer organs and tissues of the body, as well as gives solidity to the limbs for the purpose of locomotion. Ox bone is composed of about 30 parts by weight of animal matter, which gives it elasticity, to 70 parts of earthy matter, principally salts of lime, giving it hardness and rigidity. Each bone is covered with a membrane called the periosteum, which by means of the minute bloodvessels *it contains, nourishes and supplies it with blood. The separate bones comprising the skeleton of the horse are about 252 in number.* The skull, *divided into the cranium and face,* consists of 32 bones, 12 of which go to form the cranium, containing the brain, and 20 to form the face. The hyoid bones giving support to the tongue and larynx, and the os rostrum found in the snout of the pig, are also enumerated with the facial bones. The vertebral column is divided into cervical, dorsal, lumbar, sacral, and coccygeal vertebræ. These may be seen in the following table to vary in number in the domesticated animals:—

	Horse.	Ox	Sheep.	Pig	Dog
Cervical (neck) .	7	7	7	7	7
Dorsal (bearing ribs) .	18	13	13	14	13
Lumbar (loins) . .	6	6	6	6 or 7	7
Sacral (croup) . . .	5	5	4	4	3
Coccygeal (tail) ...	18 to 20	18 to 20	18	20 to 23	18 to 22

THE THORAX is formed by the dorsal vertebræ, the ribs with their costal cartilages, and the sternum or breast bone. The ribs (always the same number as the dorsal vertebræ) are divided into true and false. The true are those which directly join the sternum by their cartilages; the false are not directly united to the sternum, but to the cartilages of the true ribs. The ribs of the ox are straighter and broader than those of the horse. The sternum forms the floor of the chest, and comprises a number of originally distinct pieces. In the horse it is laterally compressed, and consists of 6 or 7 bony segments. In the ox it is flattened from above downwards, and contains 7 segments. It is also flattened in the pig, and has 6 segments. In the dog and cat it is composed of 8 pieces, constricted at their middle and bulging at the ends, resembling the tail vertebræ of the horse. The pelvis, or pelvic girdle, situated posteriorly on the spinal column, is formed by the two haunch bones, the sacrum, and one or two coccygeal bones.

THE FORE OR ANTERIOR LIMB consists of the following bones.—

Scapula or shoulder blade.

Humerus (upper arm).

Radius and ulna (forearm). These two bones are early fused in the horse, ox, and sheep. In the pig they are closely united by ligament, but, although they remain separate, are immovable. In the dog and cat these bones enjoy considerable latitude of motion upon each other, being united by a joint at either extremity.

Carpus, or knee bones (representing the human wrist), presenting the following variations: horse, 7 or 8; ox, 6; pig, 8; and the dog, 7 bones.

Metacarpal, or cannon bones. Horse has 3: one middle large metacarpal, and an external and internal splint bone or small metacarpal. The ox has one large metacarpal and one external splint bone. The pig has 4 metacarpals, the two middle ones being the larger. The dog has 5, the innermost one (thumb) being the smallest.

Sesamoids (situated at lower extremity of metacarpal bone). Horse, 2; ox, 4; pig, 8; and the dog, 10 bones.

Os suffraginis, or large pastern.
Os coronæ, or small pastern.
Os pedis, or coffin bone, and the
Os naviculare, or shuttle bone.
} phalanges.

The Hind or Posterior Limb consists of the following:—

The femur, or thigh bone.

The patella, or stifle.

The tibia and fibula, or leg bones (the fibula may be more or less suppressed).

The tarsus, or hock, like the carpus, consists of several bones (representing the human ankle and heel). horse, 6; ox, 5; pig, 7; and dog, 7.

Metatarsal bones. Horse has 3, viz. a middle large one, and an internal and external small metatarsal.

The phalanges: the bones forming these are similar to those of the fore limb, and bear the same names.

Bones are met with in other situations, *e.g* the os cordis found in the heart of the ox.

The Digestive System.—The alimentary canal is a musculo-membranous tube extending from the mouth to the anus. It is variously named in the different parts of its course, and is divided into the mouth, pharynx, œsophagus, stomach, small intestine, large intestine, and rectum.

The stomach of the *horse* lies across the abdominal cavity posterior to the liver The internal, or mucous coat, is divided into right and left halves. The right, or pyloric, or villous, is lined with red mucous membrane, soft and vascular, seen to be honeycombed when viewed with a lens, and containing the gastric follicles or glands which secrete the gastric juice. The left, or cardiac, or cuticular, is white, and may be considered a continuation of the mucous membrane of the œsophagus, *i.e.* the tube leading from the mouth. The line of demarcation between the two halves is very sharp and dentated, and is called the cuticular ridge. At the pyloric ring arises the small intestine (about 72 ft in length), divided into the duodenum, the jejunum, and the ileum, the last terminating in the cæcum, in what is called the ileo-cæcal valve, a ringlike fold of mucous membrane which prevents the passage of the contents of the cæcum back again into the ileum. The mucous coat of the small intestine is soft, red, and vascular, and provided with a variety of glands and fingerlike projections, known as villi, in which arise the absorbent vessels. The large intestine (about 25 ft. in length) is divided into cæcum, colon, and rectum, the latter opening to the exterior by the anus.

The stomach of *ruminants* is divided into four compartments, viz. the rumen, the reticulum, the omasum, and the abomasum; the three first may be considered as dilatations of the œsophagus, the fourth being the true digestive stomach.

(*a*) The rumen or paunch has its mucous membrane studded with fingerlike or conical projections, and occupies about three-fourths of the abdominal cavity, and has a capacity of from 50 to 60 gal. in the ox.

(*b*) The reticulum, or king's hood, or honeycomb, is the smallest compartment, its mucous membrane having a honeycomb or netlike appearance; it is furnished with two openings, viz. one into the left sac of the rumen, and the other into the omasum. The œsophageal groove or gutter is formed by two muscular pillars running along the lesser curvature of the reticulum, these conducting the remasticated food from the œsophagus to the third stomach.

(*c*) The omasum, or psalterium, or manyplies, the mucous membrane of this division being raised up into a number of deep folds, placed longitudinally and of different sizes, lying side by side like the leaves of a book, and having their free surfaces studded over with papillæ of different sizes. The food in this division undergoes a crushing or rubbing-down process between the folds. This division has also two openings, a right opening into the reticulum, and a left into—

(*d*) The abomasum, or reed, or true digestive stomach, a pear-shaped sac with its mucous membrane similar to that of the stomach of the horse.

The small intestine of the ox is twice the length of that of the horse, but smaller in diameter, and the large intestine is about 36 ft. in length.

The stomach of the *pig* is simple, and not unlike that of the horse in shape, and has a small cuticular area of about 2 or 3 in. surrounding the cardiac orifice; it is also furnished at the cardia with a conical *cul-de-sac*. Its capacity may be from 1 to 2 gal. The small intestine is about 56 ft. in length. The cæcum has three longitudinal bands, like that of the horse, but the apex is rounded like that of the ox.

The accessory glands in connection with the alimentary canal are:—

(*a*) The salivary glands, opening into the mouth, and named the parotid, the submaxillary, and the sublingual, the latter gland being double in the pig and absent in the dog.

(*b*) The liver, the largest gland in the body. In the horse it weighs from 9 to 11 lb. It is situated between the stomach and diaphragm. It has a double blood supply: (1) the portal vein, supplying it with functional blood, *i.e.* blood loaded with the materials absorbed from the stomach, spleen, pancreas, and intestines; (2) the hepatic artery, supplying nutritive blood to the gland itself. All the domesticated animals, with the exception of the horse, possess a special bag or bladder for the storing up of the bile.

(*c*) The pancreas or sweetbread, a pale-pink-coloured gland, lying in close relation to the stomach and small intestine

The spleen is a ductless gland, situated on the left side of the greater curvature of the stomach.

The Respiratory Organs comprise the following: nostrils, larynx, trachea, bronchial tubes, and lungs.

The lungs, right and left, are two semi-conical spongy bodies contained in the thorax, each enclosed in its own pleural membrane. Their external faces are in contact with the ribs; their internal with the œsophagus and the aorta. There is also found the depression for the lodgment of the heart (enclosed in its pericardium), with the root of the lung behind and above it.

The lungs, like the liver, have their blood supply of two kinds: (*a*) venous or functional blood, *conveyed by the pulmonary artery to be oxygenated*; (*b*) arterial or nutritive blood for the organ itself.

The pericardium is a fibro-serous sac, in which *the heart is contained. It is conical in shape;* its apex is attached to the upper surface of the *sternum, and its base is connected with the large* vessels entering and leaving the heart.

THE HEART is a conical, hollow, muscular organ. In the horse it is situated between and below the lungs, and opposite the 3rd, 4th, 5th, and 6th ribs, and suspended from the spine by the large bloodvessels. It measures from the base to the apex about 10½ in., and about 7½ in. at its greatest diameter. It weighs from 5 to over 6 lb. The heart is divided by a vertical partition into two halves, these being again divided by a transverse septum, so forming four chambers, viz. 2 auricles and 2 ventricles.

THE KIDNEYS are two organs situated on either side of the vertebral column a little behind the attachment of the diaphragm. They lie against the dorsal wall of the abdominal cavity. The anterior end of the right kidney contacts the posterior surface of the liver, and is heart-shaped, and simple in the horse. In the ox the kidneys are lobulated; but in the other domesticated animals they are simple, like those of the horse.

THE NERVOUS SYSTEM is divided into four parts: (*a*) the brain, comprising the cerebrum, the cerebellum, and the medulla oblongata; (*b*) the spinal cord; (*c*) the nerves; and (*d*) the sympathetic nervous system. The cerebrum is the seat of the will, emotions, and intellect, the cerebellum regulates movement; and the medulla oblongata performs a similar function The spinal cord passes back to the sacrum, within the tube formed by the vertebræ, and in its course gives off the—

Spinal nerves.—There are 42 or 43 pairs of these, which supply the different parts of the body. Their relative numbers in the different regions of the vertebral column are: cervical, 8; dorsal, 18; lumbar, 6; sacral, 5; and coccygeal, 6 or 7. These nerves are divided into two classes, sensory and motor; the sensory conveying impulses from the body to the brain, and the motor conveying impulses from the brain to the body.

The sympathetic system consists of two long white cords, one lying on each side of the under surface of the vertebral column (having at intervals little swellings of nervous matter called ganglia), and lie close to the heads of the ribs; each cord is continued backwards into the abdomen and forwards into the head. This system gives off branches which supply the heart, stomach, liver, pancreas, kidneys, and intestines. [J. M.]

Compensation for Unexhausted Improvements.—Under the Agricultural Holdings Act of 1906, as under its predecessor of 1900, compensation is allowed to a tenant of a farm who has effected certain improvements on it, but the full benefit of which he has not been able to reap by the time of his quitting the holding. These improvements are set out in the Act, and are variously grouped in a *Schedule according as they are (a) those for* which the consent of the landlord must be first obtained, (*b*) those of which notice must be given to the landlord, (*c*) such as require neither *consent of landlord nor notice to be given. These improvements comprise a large number of different operations, such as the laying down of* permanent pasture; the planting of hops, fruit trees, &c.; drainage; liming of land; the application of purchased artificial and other manures; the consumption on the holding of cake, corn, &c., purchased from outside; the consumption on the holding of corn grown on the farm itself. It is around the three last-named subjects that the greatest controversy has been held, and it is these on which agricultural chemistry might be expected to throw some light. If a tenant use a certain manure, or consume on his holding a certain amount of cake or corn, it is very desirable to know how long the influence of such application will last on the land and benefit succeeding crops, and also to what extent it will benefit each crop, so that, in the event of his having to leave his farm before he has derived the full benefit from its use, he shall be able to claim from the incoming tenant what might be considered the fair 'unexhausted value' For assessing these 'compensation values' local custom, which had sprung up in different parts of the country, was, speaking generally, allowed to rule, and, with the exception of Lawes and Gilbert's Tables (which were first issued in 1875 by Sir John Lawes, and later by him, with Sir Henry Gilbert, in 1885), there was no serious attempt to deal with the question on a scientific basis. Even the Tables of Lawes and Gilbert, which were revised and brought up to date by them in 1897 and 1898, did not commend themselves generally to the practical farmer, and, though it was allowed that they proceeded on a sound basis, they were found to be too complicated to admit of their general adoption in practice. These Tables—which are published in the Journal R.A.S.E., vol xlvi (1885), vol. lviii (1897), and vol. lix (1898)—were prepared in view of the passing of the Agricultural Holdings Act of 1883. They dealt only with the question of the manure produced by the consumption of feeding-stuffs, and did not touch on that of the use of artificial and purchased manures. Indeed, it must be at once said that on the latter question there has been as yet nothing definite set out, either in tables or otherwise, and the custom of the particular district is allowed still to rule in regard to compensation. The passing of the Agricultural Holdings Act of 1900 caused fresh attention to be drawn to the subject of 'unexhausted manurial value', inasmuch as now, for the first time, compensation was given for the consumption, on the holding, of corn grown on the farm, as well as for cake and corn purchased from outside. The Central Chamber of Agriculture felt that it was very desirable to take up the matter again, and chiefly with a view, if possible, to harmonizing the very varying practices throughout the country when assessing compensation. Accord-

ingly, a very strong committee was appointed to deal with the question, and this committee, after taking a large amount of evidence, reported in January, 1903. Shortly previous, however, to the issue of their report, Dr. Voelcker, consulting chemist of the Royal Agricultural Society of England, and Mr. A. D. Hall, director of the Rothamsted Experimental Station, had been engaged in reviewing the former work of Lawes and Gilbert in the light of further experience gathered from the Rothamsted and the Woburn experiments, and from others carried out on the Continent. They had, further, the advantage of a new set of experiments, carried out at the Woburn experimental farm, on the losses which farmyard manure undergoes in its making and storing. As the result of these, Voelcker and Hall were led to review and remodel the former Tables of Lawes and Gilbert, and the Tables as revised by them were placed at the disposal of the Central Chamber's committee before the latter's report was drawn up. Voelcker and Hall's Tables, together with an exhaustive discussion of the whole subject, were published in the Journal R.A.S.E., vol lxiii, 1902, pp 76–114. The Central Chamber's committee in effect adopted these Tables with but slight modification, the main difference between the two sets of Tables being that in the Central Chamber's Tables the period over which compensation is spread is *three* years instead of the *four* years adopted by Voelcker and Hall.

It will be desirable to briefly indicate the basis on which Lawes and Gilbert originally formed their Tables, and to note the main points in regard to which modification was subsequently found to be called for. Until the appearance of the Tables, it had been usual to base the compensation to be paid on the original *cost* of the purchased food. This was now shown to be an utterly fallacious basis, the manurial value of a food after it has been consumed having little or no relation to its original cost as a feeding material. But it is strange how long it takes to 'kill' a fallacy of this kind, and even at the present day there are Chambers of Agriculture and Valuers' Associations which persist in adopting this faulty and misleading basis of *cost*.

The Rothamsted field experiments had shown clearly that it was on the nitrogen, the phosphoric acid, and the potash of manurial substances applied to the land that the crop produce depended. Lawes and Gilbert then prepared a very full Table of the composition of the different foods used on the farm in respect of these constituents, and from a very important series of feeding experiments conducted at Rothamsted, and which comprised the analyses of the entire carcasses of the animals so fed, they ascertained what proportions of the nitrogen, phosphoric acid, and potash were respectively used up in the body increase, and what passed into the manure. To the manurial ingredients thus available for use on the field they gave money values in accordance with the prices per lb. then ruling in the market for each constituent as judged from manures in common use. The sum of these values was given as the 'original manure value'. Lawes and Gilbert then proceeded to distribute this over the period for which the manure might be expected to show any benefit. But, inasmuch as they were well aware of the many circumstances which would cause loss in the manure before it came on to the land, they started by deducting one-half the original manure value as being that which in ordinary practice would be lost. The residual value they spread over a period of 8 years—though it is not at all clear on what grounds this period was taken—and deducted for each year one-third of the value of that of the previous year. The consequence was the setting out of a Table which calculated the compensation on a period of years. Though the Tables had much to recommend them on theoretical grounds, and though they were the only ones which rested on a proper basis, they were but little used in actual practice, but were felt to be beyond the reach of the ordinary farmer or even of the average valuer. It was with the view of simplifying these Tables, if possible, that Voelcker and Hall undertook the revision of them. As the result of their work, several modifications were introduced, the principal being: (1) a revision of the unit prices for nitrogen, phosphoric acid, and potash; (2) a revision of the proportions of these constituents recovered in the manure; (3) the calculation of the compensation payable on a period of 4 years only (the four-course rotation), and lastly, the gathering up of the whole in a single Table in place of the three Tables of Lawes and Gilbert. The Central Chamber of Agriculture's committee adopted these Tables, with the single modification that they estimated the compensation on a period of 3 years only in place of 4. Voelcker and Hall's Tables were, it must be pointed out, in effect Lawes and Gilbert's revised in the light of later experimental experience and requirements, but for their main facts reliance was placed on the work of Lawes and Gilbert. The substitution of 4 years for the former 8 years period was, however, much more in consonance with practical requirements, and also the figures of loss in the making and storing of dung were the outcome of actual experiment rather than of estimate. The Tables, whether Voelcker and Hall's or of the Central Chamber, received at once a more ready acceptance at the hands of practical men, and it is satisfactory to record that, in the majority of cases, Chambers of Agriculture and Valuers' Associations throughout the country have adopted them or some trifling modification of them. The great point has been gained that the principle of real manurial value rather than of original cost of the feeding material has been accepted as the guiding rule. At the same time there are still some Chambers and Associations which retain their old basis of cost. An enquiry has recently been made by the Central Chamber of Agriculture with the view of ascertaining to what extent the new proposals have met with acceptance throughout the country. The return was published in July, 1906, and showed that out of 23 Chambers or Associations 14 had adopted the principle of compensation based on

manurial value, *taking the Tables of the Central Chamber* or *of Voelcker and Hall*, with, in some cases, slight modification. On the other hand, 8 Associations continued the old basis of cost, in spite of all that had been put forward to show the unreliability of this. Among these were the Valuers' Associations for the Midland counties, *for Notts, Suffolk, and the North* and East Ridings of Yorkshire, as well as the Staffordshire Chamber of Agriculture. The Newcastle Farmers' Club has gone very fully into the matter, and has adopted a scale of manurial values, dividing, however, compensation under three classes, according to whether the farming be of good, medium, or of low quality. On the whole, therefore, the response is fairly satisfactory, seeing that it is well known that in some of the cases, at least, where the old basis of cost is kept to, there are circumstances in the case which enable a settlement on these lines to be made without any question of arbitration coming in. For very similar reasons certain other and important Associations, such as the Lincolnshire Tenant Right Valuers' Association, and the similar ones of Norfolk, Derbyshire, Yorks, and Notts, have given no reply to the Central Chamber's application.

It is to be hoped that, as time goes on, all Chambers of Agriculture and Valuers' Associations will come to see that the real basis of all such valuations ought to be, not the original cost of a food, but that manurial value which will be left after the consumption of the food, and which will be available for the production of future crops. In this way alone can be assessed what is described in the Agricultural Holdings Act as 'the value of the improvement to the incoming tenant'.

The Tables as given respectively by the Central Chamber of Agriculture and by Voelcker and Hall are shown on this page and the following page.

The question has frequently been asked, or rather was asked when Lawes and Gilbert's Tables were the only ones existent, 'How far would these theoretical values be borne out in practice?' It was with the object of deciding this question that the Woburn Rotation Experiments were devised and were carried on for a series of sixteen years (1877–94), without, however, throwing any definite light on the point. That this was the result is attributable to what was not then understood, but which the researches of Hellriegel subsequently explained, viz. the influence of the clover crop in the rotation. Plots on which roots were fed off by sheep receiving decorticated cotton cake (rich in nitrogen) gave better barley crops than those on which roots were fed off with maize meal (poor in nitrogen); but when a clover crop followed, the succeeding wheat was just as good whether cotton cake or maize was fed, the clover crop having, as we now know, taken up free nitrogen from the air, and it produced in consequence a wheat crop as good in one case as in the other. The experiment has, however, now been restarted, and without the intervention of a clover crop, and it is hoped that in this way the differences will be brought out.

Central Chamber of Agriculture's Average Scale of Compensation, for Unexhausted Manurial Value, of the following Food Stuffs, per Ton Consumed, based on the Article by Dr. Voelcker and Mr. A. D. Hall, in the Journal of the R.A.S.E., Volume LXIII, which brings the Articles by Lawes and Gilbert on Compensation for Food Values up to Date.

Food	Consumed during Last Year. Per Ton.	Consumed during Last Year but one Per Ton.	Consumed during Last Year but two. Per Ton.
	£ s d.	£ s. d	£ s. d.
Decorticated cotton cake	2 16 0	1 8 0	0 14 0
Rape cake	2 0 0	1 0 0	0 10 0
Linseed cake ...	1 18 0	0 19 0	0 9 6
Malt culms	1 16 0	0 18 0	0 9 0
Undecorticated cotton cake ...	1 14 0	0 17 0	0 8 6
Cocoanut cake, Linseed ..., Beans ..., Peas ..., Bran ..., Pollard	1 10 0	0 15 0	0 7 6
Dried grains ..	1 4 0	0 12 0	0 6 0
Palm-nut cake	1 0 0	0 10 0	0 5 0
Malt, Wheat ..., Barley .. ..., Oats ..., Maize, Rice meal	0 14 0	0 7 0	0 3 6
Locust beans ...	0 12 0	0 6 0	0 3 0
Mangels, swedes, turnips	0 2 6	0 1 6	—
Pure clover or sainfoin hay	1 0 0	0 10 0	—
Hay	0 15 0	0 7 6	—
Straw	0 7 0	0 4 0	—

In assessing the unexhausted manurial value of purchased and other foods, it has to be remembered that many circumstances will cause this to require some modification. It must make a difference, for instance, whether the manure be made in closed boxes and in covered yards, or in open yards, whether it be exposed to rain or not, the class of stock used in making it, whether they be young, or else fattening bullocks, or milking cows, and whether the food be given on pasture or on arable land. All these are points which should be left with the valuer to take account of; the Tables are not meant to be more than a guide, to give the basis of fair calculation of what might be expected to occur in the case of farmyard manure kept and used under ordinary good conditions. But it is not intended by them to replace the valuer or to prevent the free exercise of his judgment.

Coming next to the question of compensation for the unexhausted values of artificial and other manures used on the land, it must be at once said that there is but little experimental evidence that is available for calculating

VOELCKER AND HALL'S COMPENSATION TABLES, PUBLISHED IN ROYAL AGRICULTURAL SOCIETY'S JOURNAL, 1902.

No.	Foods.	Valuation per Ton as Manure: Nitrogen: Per Cent in Food	Nitrogen: Value at 12s per Unit I	Nitrogen: Half of Value to Manure	Phosphoric Acid: Per Cent in Food	Phosphoric Acid: Value at 3s per Unit. II	Phosphoric Acid: Three-quarters of Value to Manure	Potash: Per Cent in Food	Potash: Value at 4s per Unit, all to Manure III.	Compensation Value for each Ton of Food Consumed: Last Year.	Second Year.	Third Year.	Fourth Year.
		Per cent	s d	s d.	Per cent	s d	s d	Per cent	s d	s d	s d	s d.	s. d.
1	Decorticated cotton cake	6 90	82 10	41 5	3·10	9 4	7 0	2 00	8 0	56 5	28 2	14 1	7 0
2	Undecorticated cotton cake	3·54	42 6	21 3	2·00	6 0	4 6	2·00	8 0	33 9	16 10	8 5	4 2
3	Linseed cake	4·75	57 0	28 6	2·00	6 0	4 6	1 40	5 7	38 7	19 3	9 7	4 9
4	Linseed	3 60	43 2	21 7	1 54	4 7	3 5	1·37	5 6	30 6	15 3	7 7	3 9
5	Palm-nut cake	2·50	30 0	15 0	1 20	3 7	2 8	0 50	2 0	19 8	9 10	4 11	2 5
6	Cocoanut cake	3·40	40 10	20 5	1·40	4 2	3 1	2·00	8 0	31 6	15 9	7 10	3 11
7	Rape cake	4 90	58 10	29 5	2 50	7 6	5 8	1 50	6 0	41 1	20 6	10 3	5 1
8	Beans	4·00	48 0	24 0	1·10	3 4	2 6	1 30	5 2	31 8	15 10	7 11	3 11
9	Peas	3·60	43 2	21 7	0 85	2 7	1 11	0 96	3 10	27 4	13 8	6 10	3 5
10	Wheat	1 80	21 7	10 9	0 85	2 7	2 0	0 53	2 1	14 10	7 5	3 8	1 10
11	Barley	1·65	19 10	9 11	0·75	2 3	1 8	0 55	2 2	13 9	6 10	3 5	1 8
12	Oats	2·00	24 0	12 0	0 60	1 10	1 5	0 50	2 0	15 5	7 8	3 10	1 11
13	Maize	1 70	20 5	10 2	0 60	1 9	1 4	0 37	1 6	13 0	6 6	3 3	1 7
14	Rice meal	1·90	22 10	11 5	0 60	1 9	1 4	0 37	1 6	14 3	7 1	3 6	1 9
15	Locust beans	1·20	14 5	7 2	0 80	2 5	1 10	0 80	3 2	12 2	6 1	3 0	1 6
16	Malt	1 82	21 10	10 11	0 80	2 5	1 10	0 60	2 5	15 2	7 7	3 9	1 10
17	Malt culms	3·90	46 10	23 5	2 00	6 0	4 6	2·00	8 0	35 11	17 11	8 11	4 5
18	Bran	2 50	30 0	15 0	3 60	10 10	8 2	1 45	5 9	28 11	14 5	7 2	3 7
19	Brewers' grains (dried)	3 30	39 7	19 9	1·61	4 10	3 8	0 20	0 10	24 3	12 1	6 0	3 0
20	Brewers' grains (wet)	0·81	9 9	4 11	0 42	1 3	0 11	0·05	0 2	6 0	3 0	1 6	0 9
21	Clover hay	2 40	28 10	14 5	0 57	1 9	1 4	1 50	6 0	21 9	10 10	5 5	2 8
22	Meadow hay	1 50	18 0	9 0	0 40	1 2	0 11	1·60	6 5	16 4	8 2	4 1	2 0
23	Wheat straw	0·45	5 5	2 8	0 24	0 9	0 7	0 80	3 2	6 5	3 2	1 7	0 9
24	Barley straw	0 40	4 10	2 5	0 18	0 6	0 4	1·00	4 0	6 9	3 4	1 8	0 10
25	Oat straw	0 50	6 0	3 0	0·24	0 9	0 7	1·00	4 0	7 7	3 9	1 10	0 11
26	Mangels	0·22	2 8	1 4	0·07	0 3	0 2	0 40	1 7	3 1	1 6	0 9	0 4
27	Swedes	0·25	3 0	1 6	0·06	0 2	0 1	0·22	0 11	2 6	1 3	0 7	0 3
28	Turnips	0 18	2 2	1 1	0·05	0 2	0 1	0 30	1 2	2 4	1 2	0 7	0 8

this. At the present time a series of experiments is going on at Rothamsted with the object of elucidating these very points. But, so far, one has little beyond the general experience of the practical man and the opinion of the agricultural chemist to serve as a guide. Much, too, must depend upon the kind of soil on which the manure is to be used, and the course of cropping pursued. Certain facts, however, have been clearly brought out as the result of experiment. The Rothamsted and Woburn experiments have, for instance, shown that alike on a heavy and a light soil there is practically no residual value after using a dressing of nitrate of soda, and but slight residue after employing sulphate of ammonia. On the other hand, soils retain both phosphates and potash to a marked degree, and it would be but fair to allow consideration for the use of manures containing them. Bones and other more slowly-acting manures, while not so rapid in action, will last longer in the soil, and of the same nature are fish and meat manures, Peruvian and other guanos, shoddy, wool dust, &c., also insoluble phosphatic materials like basic slag. In all these cases the assessment of manurial value on the basis of original cost is not open to the objections urged in the case of feeding materials, for it is the manurial value which in large measure fixes the cost. As a general principle, the influence of bones on grass land is taken as extending over from 6 to 8 years, and on arable land 4 years. More soluble manures, such as dissolved bones, superphosphate, &c., are not usually reckoned as lasting on arable land above 3 years. With regard to lime, we have more definite information from the Woburn experiments, these having clearly shown that the influence of lime will tell on arable land for from 8 to 10 years, and on pasture probably from 12 to 14 years. Basic slag is generally reckoned as lasting from 4 to 5 years on grass land. But in regard to all these points there is great diversity in local practice. Moreover, when one comes to consider the subject more closely, it is almost inevitable that this should be so, for it has been abundantly shown that on certain lands, on the dairy pastures of Cheshire, for example, bones, both ground and boiled, have an especial value, whereas in some other parts of the country they seem to have but little effect. This is also the case elsewhere with dissolved bones, while in regard to basic slag it is generally recognized that it does but little good to light soils, but is frequently of the highest value on cold, heavy, rather poor, clay land. Hence, in giving compensation for the unexhausted manure value of manures, one ought really to take into consideration whether they have been used judiciously or not, whether they are such as are likely to suit the particular soil, and also one ought to have some guarantee that they have been of the quality represented. It would appear, therefore, very difficult to draw up a scale of values applicable to manures, and to the different districts in which they have been used. Consideration must also be given to the question whether they have been used on arable land or on grass land, and in the latter case whether the grass has been mown for hay or fed. In Cheshire it is usual to allow compensation for ground bones over a period of 8 years when used on pasture, and over 7 years for boiled bones similarly used. In Devonshire, on the other hand, compensation is given for 5 years only. Similar differences are found with regard to the use of lime or chalk; for, whereas in Cheshire and Devonshire only about 5 years are allowed for, in other parts of the country allowance is given up to 10 and 12 years, and, according to the scale of the Newcastle Farmers' Club, up to 10 years for arable land and 20 years for pasture in the first class of land. Where, as in the last-named district, there exists the division into classes according to the conditions favouring improvement or the reverse, the difficulty would, no doubt, be accentuated, and the Central Chamber of Agriculture, in reviewing the proposals of the different Associations, could not favour the scheme of land classification, considering that it would not prove sufficiently elastic to fairly meet all cases.

In regard to compensation for drainage, there exist similar diversities of practice in different parts. Much must depend on the nature of the work, the kind of soil, the material used, how far the work is called for, and other points which do not allow of ready definition. In Cheshire, draining is considered to last for 7 to 14 years, and in Bedfordshire for 10 years, whereas the scale of the Newcastle Farmers' Club allows of variations from 15 years in the third class to 35 years in the first class. Such wide differences would seem to require more than ordinary explanation. The Central Chamber's committee found themselves here, too, unable to fix any scale, but considered that this should be a matter of arrangement beforehand between landlord and tenant. The laying down of pasture was another matter taken up in view of the paying of compensation, and considerable difference of opinion was expressed as to when a pasture ceased to be a 'temporary' one.

In regard to other matters forming the base of compensation, those included under Part I of the Schedule to the new Act of 1906—such as buildings, &c.—are those which require the consent of the landlord, and, being such, they ought to be matter of covenant. Dilapidations, however, cover not only the repair of buildings, fences, &c., but also the question of foul land. It is obvious that on such a point as whether land is foul or not, or to what extent the land is injured thereby, there must be room for endless disagreement, and widely differing views may be expressed as to the amount of compensation to be paid in respect of land being foul. It would seem impossible to fix any scale for this, but each case must clearly be taken on its own merits or demerits. [J. A. V.]

Compositæ.—This is a nat. ord. of dicotyledonous plants which includes amongst its members thistles, daisies, and dandelions. In the vegetable kingdom, the Composites are considered to occupy the same high and commanding position that Man does in the animal kingdom. The

flowers, for example, never work separately and independently, but a whole cluster of them aggregate together into a common head, and co-operate for the common end of successful reproduction. To get quite close together the flowers dispense altogether with a stalk and become sessile as it is called. In this close union, a calyx for the usual protective purpose becomes a superfluity, and accordingly the sepals are either dispensed with altogether as in the daisy, or become transformed into a tuft of hairs or feathers crowning the fruit, which the wind wafts away to settle down and occupy new territory. A fruit distributor of this nature bears the special name of *pappus*, and is well exemplified by thistle down. Provided with such cunningly contrived reproductive machinery, one is not surprised to learn that the Composites are the most extensive of all the natural orders in the vegetable kingdom. Neither is one surprised to find our teachers and our poets speaking of the flower-head of the daisy as if it were one flower, and not a whole host of tiny flowers so closely compacted that the whole head looks like but one flower. It is good poetry and good English to describe the daisy as 'the wee crimson-tipped flower', though incorrect from the botanist's point of view.

In the Composites there is a protective and defensive arrangement common to the whole head, namely, a special set of modified leaves completely surrounding a whole cluster of flowers. This set of leaves around the head is called *involucre*, and is often confounded with a calyx. The thistle head exemplifies the defensive spiny sort of involucre, and the head of burdock, another Composite, that sort of involucre which not only protects but hooks itself to the wool of passing sheep or to the clothing of man, and thus plays the extra part of a fruit distributor.

There is only one other natural order of plants which invariably aggregates its flowers together into the form of an involucrate head, namely the teazel order (*Dipsaceæ*). Distinction from Composites is, however, easy when attention is paid to the anthers of the stamens. In the teazels, the anthers are quite distinct from one another and easily noticeable, whereas in Composites the anthers grow together into a sort of chimney, filled with pollen instead of soot, and one not on the alert might get the idea that in the Composites there are no stamens at all, or, if very ignorant of botany, one might mistake the yellow flowers of a daisy for the stamens, the white flowers for the petals, and the involucre for the calyx.

In various natural orders it occasionally happens that the more specialized members arrange the flowers in heads. Clover, among leguminous plants, is a case in point, but here there is no involucre round the head.

The ovary of a Composite is a very characteristic structure; it is always on the outside of the flower, always has but one chamber containing one ovule attached at the base, and there is one style projecting from the apex. When this ovary is ripe it is still very characteristic: it is composed of a hard seedbox which does not open, and attached to the inside at the base there is a single seed. This fruit looks like a seed, and is often misnamed 'seed'; its technical name is *cypsela*. The 'seed' of Sunflower, for example, is only seed in name; it is really the genuine Sunflower fruit—its *cypsela* in fact.

The distinctive characters of Composites are: (1) The flowers are arranged in involucrate heads. (2) The petals are grown together. (3) The ovary is on the outside of the flower, one-celled, and one-seeded. (4) The five stamens are inserted on the petals, and the five anthers cohere so as to form a tube.

This large order is divided into three sub-orders: (1) All the flowers are tubular—Tubulifloræ. (2) Some of the flowers are tubular, the rest ligulate—Diversifloræ. (3) All the flowers are ligulate—Ligulifloræ. If a flower is detached from a thistle head or from a cornflower head, the corolla is seen to have the form of a tube. Thistle and cornflower are thus representatives of sub-order 1, Tubulifloræ. If a white flower is detached from the ray of a daisy head, the corolla is seen to be strap-shaped, that is, ligulate. If a yellow flower is detached from the centre of the head, the corolla is seen to be tubular. Daisy is thus a representative of sub-order 2, with diverse flowers, Diversifloræ. If a flower is detached from a dandelion head, the corolla is seen to be strap-shaped, or ligulate, and all the corollas have this shape, therefore the dandelion is a representative of sub-order 3, Ligulifloræ.

In connection with this division of Composites into three sub-orders, we must be careful to note that what we here call Tubulifloræ is called in some botanical works Cynarocephalæ, and what we here call Diversifloræ is called Tubulifloræ. The Ligulifloræ have milky juice (latex), the Diversifloræ and Tubulifloræ watery juice. Milk Thistle (Sonchus) is accordingly only a thistle in name, for its juice is milky and not watery, and all its flowers are ligulate and not tubular as in a genuine thistle.

IMPORTANT CULTIVATED COMPOSITES ARE—

Diversifloræ: Sunflower (*Helianthus annuus*), an annual grown for its oily 'seeds' (cypsela fruits). Yarrow (*Achillea Millefolium*), a perennial grown on sandy permanent pastures for sheep feed. Jerusalem Artichoke (*Helianthus tuberosus*), a perennial grown for its tuberous underground stems.

Ligulifloræ: Chicory (*Cichorium Intybus*), a blue-flowered perennial, grown for forage in permanent pastures, and often for its roots.

IMPORTANT WEEDS ARE—

Tubulifloræ: flowers all tubular. Creeping or Field Thistle (*Carduus arvensis*), a purple-flowered perennial. Spear Thistle (*Carduus lanceolatus*), a purple-flowered biennial. Marsh Thistle (*Carduus palustris*), a purple-flowered biennial of moist pastures. Cornflower (*Centaurea Cyanus*), a blue-flowered annual or biennial in corn. Hardhead or Knapweed (*Centaurea nigra*), a purple-flowered perennial in pastures.

Diversifloræ: some of the flowers tubular,

some ligulate. Corn Chamomile (*Anthemis arvensis*), an annual in corn. Mugwort (*Artemisia vulgaris*), a perennial on light sandy land. Daisy (*Bellis perennis*), a perennial in pastures, a sign of poverty. Ox-eye Daisy (*Chrysanthemum Leucanthemum*), a perennial in corn and poor clay pastures. Corn Marigold (*Chrysanthemum segetum*), an annual in corn, with the ray flowers yellow, not white as in Ox-eye. Ragweed, or Ragwort (*Senecio Jacobæa*), a yellow-flowered perennial in good pastures on deep land. Groundsel (*Senecio vulgaris*), a yellow-flowered annual in corn. Coltsfoot (*Tussilago Farfara*), a yellow-flowered perennial which flowers in spring before making leaves.

Liguliflorœ: all the flowers ligulate; juice milky. Smooth Hawk's-beard (*Crepis virens*), a yellow-flowered annual or biennial in dry pastures. Mouse-ear Hawkweed (*Hieracium Pilosella*), a yellow-flowered perennial in dry pastures. Long-rooted Cat's-ear (*Hypochœris radicata*), a yellow-flowered perennial in pastures. Nipplewort (*Lapsana communis*), a yellow-flowered annual in arable land. Autumnal Hawkbit (*Apargia autumnalis*), a yellow-flowered perennial in pastures. Dandelion (*Taraxacum officinale*), a yellow-flowered perennial. Field Sow-thistle (*Sonchus arvensis*), a yellow-flowered cornfield perennial. Annual Sow-thistle (*Sonchus oleraceus*), or Milk Thistle, a yellow-flowered cornfield annual. Yellow Goat's-beard (*Tragopogon pratensis*), a yellow-flowered perennial in pastures [A. N M'A.]

Composts.—Composts is the name given to a mixture of fertilizers. The object aimed at in making them is to increase the value of certain low-class manurial substances of the nature of refuse material by mixing them together; the advantage of mixing being that the combined influence of the components thus mingled is anticipated to be greater than the sum of their several fertilizing effects if they were separately used. Compost making also helps to preserve the manurial ingredients of some readily decomposable fertilizers, and further it brings into use substances which, unless applied in mixtures, would not be made use of for manurial purposes.

The objection to the making of composts lies in the expenditure involved in the labour of mixing, and in the application of bulky manures, compared with the greater portability and certainty of effect of artificial manures. The labour and inconvenience involved in the making of composts may, however, be materially diminished if the work is undertaken at suitable times and seasons, that is during the less busy times of the farm Composts are used to a greater extent in horticultural practice than in farming practice.

The following is a list of some of the principal substances used for making composts: Farmyard manure, animal substances, such as carcasses of dead animals, blood, fish, blubber, &c.; offal, leaves, rushes, weeds, turf, road scrapings, sawdust, spent bark, peat, scourings from ditches, ponds, &c., woollen rags, shoddy, mill dust, soapers' waste, paper waste, glue refuse; refuse from starch mills, provision curers, and sugar works; horn shavings, apple refuse, &c. Invariably soil with chalk or ashes is added. The best way of making a compost is to build a heap, with alternate layers about 1 ft. in thickness, of the material to be used, with a covering of earth on the top. After decomposition has commenced, it should be turned and thoroughly mixed; again made into a heap, covered with ashes and earth, and allowed to stand for some time before use. If liquid manure is available, an occasional watering with that is of great benefit.

The value of composts, apart from the organic matter they contain, depends upon the richness or otherwise of their chemical composition, and upon the amount of plant food present in an available form. The mineral matter, though of value, is not of the same importance as the nitrogenous matter, because of the possibilities of losses occurring in the latter constituent, and of its greater intrinsic value. For this reason, in the making of composts differences in the rate of fermentation, and the likelihood of losses resulting therefrom, constitute a factor of prime importance Nitrogenous material of animal origin undergoes fermentation much more rapidly than the nitrogenous matter from vegetable and other sources. The addition of much lime salts alone increases the putrefactive tendency, and likewise increases the probability of loss of ammonia, whilst the addition of earth containing a little chalk will to some extent retard this action, and at the same time absorb any ammonia formed. If it is desired to use some inert material containing nitrogen, it is better to mix it with a highly fermentative component under the conditions most suitable for decomposition to proceed. The compost heap must contain some chalk or ashes, must be kept moist, and not be too much compressed. The contact of the inert with the active material is of service in the decomposition of the former. The change of the inert nitrogen—a form in which this element occurs in many substances—into an active and available form is one of the objects aimed at, and constitutes one of the main arguments in favour of the practice of compost making Particular attention should be bestowed upon the preservation of the nitrogenous constituents of the compost, conditions might arise in which the loss of nitrogen would more than counterbalance the benefits derived from its conversion from a dormant state into an available form. Thus, if farmyard manure were mixed with such manures as blood, fish, &c., the loss of nitrogen as ammonia might be considerable, unless due precautions were taken—such as the addition of earth—which would retard fermentation and at the same time absorb ammonia salts.

Compost making is of value in preserving the nitrogenous portion of animal refuse, such as in the carcasses of dead animals, blood, fish, liquid sewage, &c., by mixing with earthy and vegetable refuse. In addition to the nitrogenous constituents of composts, the mineral matter is of equal value as a plant food, and the richness or otherwise of the mineral matter in the components of composts is a matter of consider-

able importance. Apart from the value of the plant foods contained in composts, the amount of humus they supply, and the effect of the latter upon the mechanical and physical properties of soils, supplies another undoubted argument in favour of the practice of compost making. The slow manurial action of composts is likewise of particular value to many market-garden and other plants [R. A. B.]

Compulsory Taking of Land.—While in theory a man is the absolute owner of the land he possesses, the State has always claimed the right to retake land for purposes of public utility on the ground that 'the exclusive right of a landowner yields wherever public interest or necessity requires it should yield'. This is the principle on which parliamentary powers are granted to the promoters of undertakings of a public nature whereby they are empowered to take compulsorily for the purposes of the scheme, lands belonging to private individuals on payment of due compensation Prior to the year 1845 it was customary to insert the compulsory powers in the various private Acts. In order to avoid the unnecessary expense of printing similar provisions in each Act, and to promote uniformity in the methods adopted, a series of Acts have been passed, of which the foundation was the Lands Clauses Acts of 1845, whereby the rights of parties were regulated and machinery provided for the compulsory acquisition of land. The compulsory powers cannot be put in force until the whole capital of the company or estimated sum for defraying the expenses of the undertaking have been subscribed, and lands can only be acquired compulsorily for the purposes of the Act. The compulsory powers cannot be exercised after the expiration of the period prescribed in the special Act, or, if no period be prescribed, after the expiry of three years from the passing of the Act, except in the case of lands inadvertently omitted from the notice to treat. [D B]

Concrete.—Concrete is the hard material composed of Portland cement and fragments of stone or other hard stuff and sand which is now so much used for floors and other parts of buildings. Portland cement, as described under head of CEMENT, has the property of 'setting' as firm and compact as almost any of our hardest stones when it is brought in contact with a sufficiency of moisture. Soft and easy to manipulate when newly mixed, concrete of this kind lends itself as easy of application to many purposes, and in many situations where it would be tedious if not difficult to apply stone for the end in view. On this account, together with its hard-setting property referred to, concrete is exceedingly useful as a building material generally. In fact, in nearly every case where stone can be used concrete may be substituted for it; in many cases it is superior to stone. At one time it was strongly advocated as a medium for the walls of farm cottages and buildings of a similar nature; and wherever gravel is abundant the idea seems practicable enough. We have never seen it put to practice in this way to any great extent, however.

Concrete is eminently useful as a floor-laying substance at the farm. Throughout the homestead, except perhaps in the stalls of both stable and byre, it makes an excellent floor. The substance is impervious to damp, and it affords both a hard and a smooth surface; and it is comparatively cheap. Another of its strong points—and by no means the least important among them—is the resistance it offers to the sap-and-mine powers of the rat. In the stable stall the constant pounding from the iron heels of the horses is destructive to concrete But if the few square feet of each stall likely to be affected by the horses in this way is paved with whin or granite 'setts'. the rest of the stable may safely be given the advantage of a concrete floor. Concrete is found to be rather hard for cattle to lie upon day in and day out for weeks on end Brick is a better material to lay these parts of the floor of the byre with, but nothing beats concrete for the other parts of the floor. For the floor of the pig house also there can be no better material than concrete, excepting here again, however, that part on which the animals lie And both the threshing floor--the floor of the barn proper—and the floor of the straw barn are best finished with concrete.

Another use for concrete at the farmsteading is in the construction of the stall divisions in the byres Divisions of this kind are easily formed They are strong and lasting, and when nicely finished they look quite neat Stout wooden frames or moulds are set up where the respective partitions or travises are to stand. These are filled with prepared concrete, and kept in position until the cement has 'set' and the travis can stand alone A short time thereafter it can be polished off with a hand 'float'.

In a similar way concrete might be employed at the farm in the erection of gateposts A simple frame or mould, circular, square, or polygonal in section, just as one's tastes lie, could be easily obtained, and with this as a guide no great skill need be forthcoming in erecting a thing of the kind. The frame does not require to be the whole height of the post. It will answer if made so as to draw up, as the 'setting' of the cement proceeds from base to top, in this way allowing one part of the post to become firm before weight is put upon it. A cope or pediment, should such be considered an improvement, can be cast separately and be fixed to the top of the post by bedding it on a layer of cement.

In the preparation of concrete for foundations and floors, the hard material which is to serve as a matrix for the cement should be broken up into fragments no less than those which constitute ordinary road metal — the longest axis of each piece being 2½ in, passable 'through a 2½-in. ring' as the term somewhat indefinitely runs. Of course, wherever gravel is easily procurable it is taken as the watering-down medium of the cement. When gravel is to be the stony basis of the concrete, all stones larger than the maximum above quoted should be rejected. While gravel is quite suitable for concrete, broken-up material is better. The polished surface of the gravel stones does not offer so firm a grip to the cement as the rougher surface of

the fractured stone. Any kind of stone worthy of the name will do for concrete. Broken-up bricks, especially fireclay or composite ones, make as good material as almost any other.

If the cement be good, five parts of this broken-up stuff or of suitable gravel to one of cement is the usual proportion to mix together. In order, however, to make the mixture all the more intimate, one part of clean rough sand is added. All this it is usual, where due care is exercised in the business, to mix thoroughly together by turning it completely over twice before any water is applied thereto. At the next turning, water is poured uniformly over it. This is continued for at least three other turnings, after which the mixture ought to be ready for use. Three or four inches of this is laid on a sound basis of field stones, brickbats, or material of a similar nature, and well packed together. When this is sufficiently consolidated it receives a finishing coat of a mixture of one part of cement to one of clean sharp sand, varying in thickness from an inch upwards in accordance with the tear and wear it is likely to be subject to, and finished smooth or rough in accordance with the special purposes it is intended to serve.

There must be no earthy matter amongst the material that goes with cement to form concrete —neither among the broken-up stuff or gravel, nor the sand—otherwise the cement cannot be expected to have full effect. When such is present in the mixture, whether it be in the concrete or in the finishing coat, the action of the cement is neutralized accordingly. It is almost needless to add that the sand mixed with cement to be used as plaster or as mortar must be similarly pure, were it not the case that this precaution is so often neglected [R. H.]

Concretion. See Calculus.

Condensed Milk.—Condensed or evaporated milk is the name given to the product which is obtained by the concentration of milk in a partial vacuum, with or without the addition of cane sugar. The American variety is generally unsweetened. Condensed separated milk (as well as whole milk) is also prepared. Till quite recently condensing has been the only method for preserving milk in a portable form, but some improvements in the methods of drying milk may shortly prove serious rivals to this product. The methods of manufacture of condensed milk in Switzerland and the British Isles is as follows: 1¼ lb. of cane sugar is added to each gallon of milk, and the milk is then heated to dissolve the sugar, care being taken that the mixture does not exceed the temperature at which it will boil on being admitted to the vacuum pan. The warm milk is now sucked slowly into a large vacuum pan having a small glass window in the top half through which the operation can be observed, so that the flow may be checked if frothing occurs. By the time all the milk is in the pan the gases will have been removed from it by the pumps of the apparatus. Heat can now be applied, and the water boiled off through a condenser. By regulation of the supply of cold water to the condenser, and also of the supply of heat to the pan, frothing is avoided and the milk boiled down to about one-third of its original weight. The finished product has a density of about 1·28. One gallon of milk gives 2¼ pints of condensed milk. The American method varies slightly, the milk being first sterilized by heat without the addition of sugar; it is then concentrated in a vacuum, but not to the same extent as with the sweetened milk.

The following table shows the analyses of typical condensed milks given by Richmond:—

	Water	Fat	Milk Sugar.	Cane Sugar	Proteins.	Ash	Total
Condensed sweetened whole milk .	24 06	11·28	13·97	38·31	9 36	2·13	99·11
Separated milk	28·43	0 36	16 88	39·27	11·73	2 58	99 25
Unsweetened milk	63 47	10·22	12·98	—	10·30	2·07	99·04

The fact that the totals of the analysis fall short of 100 is stated by Richmond to be due to the slight underestimation of the milk sugar. The analysis is generally made by diluting 1 part by weight of the condensed milk with 2 parts of water; in the case of unsweetened milk the mixture may be boiled, but with sweetened milk heating is either avoided altogether or not allowed to reach a high enough temperature to affect the milk sugar. A gravimetric determination is made of the milk sugar, and a polarimetric determination of the total sugar: the difference between the results of the two determinations multiplied by 0·831 will give the cane sugar. The fat may be determined in the diluted sample by mechanical means as with milk (see Butyrometer), but a higher speed or a little longer whirling is necessary.

If condensed milk is used for infant feeding, it should be mixed with not more than 5 volumes of water to 1 of milk, and the condensed whole milk only should be used. The condensed separated milk is not suitable for this purpose. In any case, the destruction of the enzymes, and other chemical changes which take place, cause all forms of heated milks to compare unfavourably with the natural product. [J. Go]

Condiments.—Condiments are substances added to rations for stock with a view to stimulating the appetite, and possibly increasing the digestive and assimilatory powers of the animals. The various proprietary articles sold for the purpose (cattle spices, condition powders, &c.) consist in the main of mixtures of various substances of appetizing taste or smell, such as aniseed, fenugreek, gentian, liquorice, cumin, coriander, caraway, ginger, juniper berries, &c., along with a variety of salts which, when judiciously employed, are known to be capable of producing beneficial effects on the general health of

the animals, *e.g.* common salt, saltpetre, carbonate of soda, sulphate of iron, Epsom salt, Glauber salt, sulphur, charcoal.

Such preparations can, however, only be used with very great caution, as the long-continued use of strong spices may eventually lead to a chronic stimulation and catarrhal affection of the mucous lining of the stomach. This danger is largely obviated by admixture with a large proportion of some feeding meals. Most commercial condiments or condimental foods are indeed mixtures of this nature. The food ingredients most commonly employed are linseed meal, locust-bean meal, maize meal, malt, and leguminous meals. It is to be feared, however, that in many cases material of doubtful value (*e.g.* miller's refuse) is included, and there is good reason to believe that the prices charged are often very excessive.

A condimental food for cattle, made up in accordance with the following prescription, has been found very satisfactory in practice.—

Locust-bean meal	28	lb.
Maize meal	56	,,
Linseed-cake meal	20	,,
Sulphur	2	,,
Saltpetre	2	,,
Common salt	1½	,,
Fenugreek	1	,,
Gentian	½	,,
Sulphate of iron	½	,,
Aniseed	½	,,
Ground ginger	½	,,
Total weight	112	lb.

The various ingredients should be finely ground and intimately mixed together. The mixture may be used at the rate of about 2 oz. (say, a small handful) per head per day. The cost (exclusive of mixing) will at current retail prices amount to 9*s.* to 10*s.* per cwt.

It has been conclusively proved that the addition of condiments to a ration does not directly increase either its digestibility or its nutritive value. Their effect, if any, must hence be dietetic rather than nutritive, and it is only in exceptional cases (*e.g.* the feeding of unpalatable or very heavy rations, ailing animals, &c.) that any appreciable effect is to be expected. For use in such cases, provided the food ingredients contained in them are wholesome and easily digestible, the condimental foods may be regarded as worth a little more than the value calculated from their content of nutritive materials.

Under ordinary conditions there should be little necessity for condiments. If anything is required then, 'along with common salt, the best "spice" for cattle is good, sweet-smelling hay' (Kellner). Treacle and locust beans are also very useful for the purpose of rendering rations more appetizing. [C. C.]

Condition.—In the agricultural sense this word when applied to the soil refers to its state of fertility, *e.g.* a soil in a low state of fertility is said to be in 'poor condition'. The term is applied to farm animals to denote a healthy and vigorous state of the body, or the reverse.

Conduits. — The conduit and the culvert generally signify one and the same thing where estate work is concerned. But nearly every district has a term of its own for a structure of this kind. The conduit proper is a covered drain or passage for water, much larger in section than is required for the drainage of a field or of a group of fields. It is, in fact, a step above a main drain. The term implies an artificially prepared channel for a runnel or streamlet of water. It may follow the original course of the water, or it may be led by a different course altogether. In the former case the bottom and the sides of the channel will have been constructed in such a way as to promote the flow of water and at same time resist its erosive action or tendency to alter its course. It may either be open above or be covered in—for that part the conduit may take the sectional form of a pipe. The culvert, on the other hand, is a built waterway, usually arched, leading through an embankment or crossing under a roadway. It is shorter than the conduit, being more for the passage of small streams through such artificial obstructions as those referred to which happen to cross their beds. If shorter, however, the culvert is a wider and higher opening than the conduit.

There is not much skill required in the formation of either the one or the other. One is readily apt, however, to err in making the passage of each, especially of the conduit, too confined. Floods are seldom discounted sufficiently, consequently when a serious one sets in, there is often disaster to some extent in the neighbourhood of the drain that cannot afford a passage to the water as it comes. There is no need, of course, to go beyond the actual requirements of the case. These one may arrive at with some degree of accuracy, provided he knows something about the rainfall of the district, and can estimate the area that the waterway is affected by. Withal, however, unless there be a good margin allowed for excessive downfalls of rain, there is liable to be obstruction now and again at the waterway. The summer 'thunder-plump' is as much to be feared as the autumn or winter 'spate'.

It matters little what materials are made use of in constructing a conduit or culvert, so long as they are durable and are well put together. Stone for work of this kind requires to be in flattish pieces, so that good bedding is permissible. Boulders and angular fragments may serve well enough for the sides of the waterway, the bottom may be paved with them too. But they are useless to form a cover with, unless, of course, the arch is adopted, which, however, is seldom done in the case of the smaller channels. Flat stones answer for covers, soles, and side walls as well. Up to a certain size of waterway, pipes in many circumstances will be the cheapest and most effective medium. But the pipe conduit is for obvious reasons more apt to be stinted in capacity. When the conduit or culvert is of brick it is usually either circular or egg-shape in section. Were it made rectangular, covers of stone would have to be provided. Keeping the straight-sided waterway as narrow as practicable makes it all the easier for

one to find covers for the same. The wider we keep it, however, the shallower at ordinary times will be the water therein, which is an important matter wherever drains discharge into the waterway. The latter are liable to be hindered in action when their outlets are not afforded a free delivery. These it is easy to understand are likely to be often obstructed in a conduit the water within which rises quickly to begin with. A circular or oval conduit is the worst in this respect, the water rising therein at a quicker ratio to the amount received at the beginning of the flow than it does when the point of half of its capacity has been reached.

Due provision should be made against the entrance of material likely to obstruct the conduit, by means of gratings in front of the inlet thereto. It is well to have more than one of these in position. When one alone is used, and it is put close against the inlet, it is apt to become clogged with twigs and leaves and thus prevent the water getting freely into the channel. Better is it to have no grating against the inlet (or at least to have a wide-spaced one there), but to have one or more in advance a little. Even if these do become clogged in the manner indicated, the water will rise over them and get a free entry beyond into the mouth of the conduit. The opener grating there would serve to keep back a branch, while smaller fry such as the leaves that had surmounted the advance gratings could pass in freely with the otherwise unhampered water. [R. H.]

Congested Districts Act. See CROFTER LEGISLATION.

Conglomerate, a sedimentary rock composed chiefly of rounded pebbles cemented by calcareous, ferruginous, or other material. Just as a grit may be described as a coarse sandstone, a conglomerate is really a coarse grit; but it is essential that its larger constituents should be water-worn and rounded. Conglomerates are thus consolidated representatives of beaches formed on the shores of ancient lakes or seas The rusting of old iron on a modern beach, or the inflow of a spring charged with calcium carbonate into a gravel, will often form a patch of conglomerate. Naturally, it is the resisting materials, such as quartz rock, quartzite, and flint, that form the bulk of most conglomerates, since more yielding rocks are broken up, or even dissolved, upon the shore. But conglomerates of limestone pebbles are conspicuous in some parts of the Alps, and almost every conglomerate will contain a mixture of materials.

Except for the limestone conglomerates mentioned above, conglomerates, when their cement decays, yield as a rule very unpromising and gravelly soils. The Old Red Sandstone conglomerates are in places successfully planted with forests, mainly of coniferous trees; but the resisting character of the rock allows it to form elevated ridges, and cultivation can only be carried on lower down, where the finer washed-out material has been accumulated. [G. A. J. C.]

Conifers (Coniferæ) are one of the three families forming the Gymnosperm class of plants, which is characterised by having unisexual flowers, an incomplete (if any) perianth, free ovules not enclosed in an ovary, and naked seeds. The conifers are distinguishable from the other two families (Gnetaceæ, Cycadaceæ) by having alternate leaves usually pointed or needle-like, and often tufted, twigs and branches often arranged in whorls around the branches and stem, unisexual flowers without perianth, the male flowers forming deciduous catkins with anther-bearing scales, and the female bearing seeds at the base of capillary scales usually forming a cone. It is a very large family, consisting of monœcious and diœcious trees and shrubs, usually resinous, and having leaves that are generally rigid, linear, or scalelike (broad bladed only in the tribe Araucarieæ). The female flowers consist of open ovuliferous carpels, often with a second supporting scale, which are arranged spirally round the axis and ripen usually in from about six to eighteen months into hard cones. The Coniferæ family is divided into the four tribes: (1) Araucarieæ (see ARAUCARIA), (2) Abietineæ or Pinaceæ, (3) Cupressineæ (see CYPRESS), and (4) Taxaceæ (see YEW) By far the most important of these economically are the Abietineæ, embracing the seven genera of—(1) Pines (Pinus), (2) Spruces (Picea), (3) Hemlock (Tsuga), (4) Douglas Fir (Pseudotsuga), (5) Silver Fir (Abies), (6) Larch (Larix), and (7) Cedar (Cedrus), which are each treated of in a separate article. All of these consist of evergreen trees, except the Larch, and they comprise the majority of the most important trees that can be profitably grown in British woodlands. But only one genus, the Pine, and only one species of it, the Scots Pine (*P. sylvestris*), is indigenous to the British Isles. All the others have been introduced at various times

Conifers are mostly indigenous to the temperate and the subarctic zones, and form about nine-tenths of the timber imported into Britain in large and ever-increasing quantities, while the softer varieties (Spruces and Silver Firs) are now being very extensively used in the manufacture of woodpulp and cellulose for papermaking (see CELLULOSE). It would be impossible to exaggerate the importance of coniferous timber to our mining industries. The great bulk of the pitwood used in coal mines consists of pine and fir, Larch, Douglas Fir, and Scots Pine being the most resinous and durable. Our home-grown supplies of this class of wood are nothing like sufficient to supply the annual demand, and our yearly imports of pitwood alone average 2¼ million loads, or over 93,000,000 cu. ft., valued at £2,500,000.

As there has always been a constant and a growing demand both for pitwood and for the larger-sized coniferous timber needed for house-building and many other trades, and as much of this raw material can quite easily and profitably be grown on poor heather-grown land now bringing in little as pasturage or deer forests, the cultivation of coniferous timber already forms the most important branch of modern British forestry, and is likely soon to become of much greater importance through State action in the afforestation of waste lands.

In comparison with broad-leaved trees, conifers offer special advantages to landowners desirous of planting for profit. Pines and firs can usually grow well on a poorer class of soil than broad-leaved trees generally, among which the best classes of timber trees, oak, ash, and elm, make considerable demands on soil-fertility. Thus the necessary soil-preparation and the planting of conifers usually costs less than stocking land with a broad-leaved tree crop, while both the early returns, in the form of thinnings, and the mature crop of marketable timber come in much sooner than can reasonably be anticipated in the case of hardwood plantations. And these advantages speaking for the cultivation of conifers as woodland crops are all the more pronounced when it becomes a question of forming new plantations on vacant or waste land, and not merely a regeneration of timber crops that have reached their maturity.

Along with these decided advantages, however, there are sometimes serious drawbacks to the formation of very extensive conifer woodlands, which can only (and not always then) be guarded against by prudent and careful management, and by constant inspection. Owing to their heavy evergreen foliage all the conifers (except the deciduous Larch) are more exposed than the bare broad-leaved trees in winter to branch and crown breakage from heavy snowfall, or to become windfall in large masses during heavy gales which may occur in any year, and usually sweep over parts of the British Isles at least once in ten years. And when they are grown in large compact blocks, as is best suited to their cultivation and to economical supervision and management, they are more liable than broad-leaved trees to be badly damaged by fire and attacked by parasites in the shape of noxious insects and dangerous fungous diseases (*e.g* Larch canker, the worst of such diseases in Britain). Such dangers are greatest when the conifers are grown as pure crops of only one particular kind of tree, which is the easiest form in which they can be grown and tended. By the judicious mixture of different kinds, wherever the nature and the quality of the soil permit of this, these dangers can be considerably reduced, though not altogether obviated. They are therefore the unavoidable risk that is tacitly accepted when a landowner invests capital in an enterprise which he considers likely to be more profitable than any other given method of utilizing his land.

For the poorer, lighter and drier classes of soil, as also for the stiffer and moister, the pines generally, and especially our indigenous Scots Pine, with sometimes also the Larch, and the Corsican Pine on limy land, are usually the most advantageous conifer crop to grow, so long as the soil is deep and loose enough to let their strong tap-roots sink well downwards into the ground. The spruces can thrive on moister and shallower land of rather better quality; while Silver Firs, Douglas Fir, Weymouth Pine, and Larch usually only do well on a fairly deep soil permitting of their often very deep root-system being properly developed. On soil of fair average quality for the given kind of tree, the largest timber crops are yielded by Douglas Fir and Menzies or Sitka Spruce, then by Silver Fir, Common Spruce, Weymouth Pine and Larch, while the other kinds of pines and firs also give a larger outturn in timber than can be expected from hardwood crops of similar age. As to their habits of growth, the conifers vary extensively. The Larch is (along with the Birch) one of our most light-demanding trees, while some of the spruces and firs are sometimes among the most shade-enduring, and the pines occupy an intermediate position. [J. N.]

Conium. See HEMLOCK.

Connemara Ponies. — The ponies of Connemara are famous, partly because of the material out of which they were originally formed, and partly because of the conditions under which they have long been bred and reared. They have in part sprung from the small horses which reached the British Islands in prehistoric times, and the conditions under which they have lived for countless generations have endowed them with the vigour and endurance of a wild race. About two-thirds of Ireland consists of a great plain floored with mountain limestone Connemara forms part of the rugged western boundary of this great Central Plain. Separated from the plain by two rock basins—Loughs Mask and Corrib—and bounded on the north by Killary harbour, it extends southwards to within a short distance of Galway Bay The western boundary is indented by bays and channels by which the warm Atlantic water penetrates well into the interior, and thus ensures a mild climate. In the north, Connemara includes the tableland of Slieve Partry, south of which are the dome-shaped twelve Bens or 'Pins' East of the Pins lie the Maumturk Mountains, and between the Pins and Galway Bay are numerous hills separated by long valleys or wide-stretching and often well-watered moors. Connemara is hence as well adapted for maintaining herds of hardy ponies as the fertile Central Plain is for rearing racehorses and hunters. When and by which routes horses reached Ireland in post-glacial times it is still impossible to say, and it is also impossible to say how many varieties of horses flourished in Ireland before the beginning of the present era. Recent enquiries, however, indicate that during prehistoric times several species of wild horses were widely distributed over Europe There were: (1) horses built on the lines of *Equus sivalensis* of the Siwalik Hills of India, *i.e* horses about 15 hands high, characterized by long slender limbs and a long head, with the face bent downwards on the cranium as in sheep; (2) horses akin to, if not identical with, the wild horse (*E prejevalskii*) recently discovered in Mongolia, *i.e* slender-limbed forms adapted for a steppe life, with a very long, narrow face, large teeth, and powerful jaws; (3) stout horses, with a short broad head, and a long body mounted on short powerful limbs ending in broad hoofs; and (4) slender-limbed horses, with a fine small head such as we find in high-caste desert Arabs,—the coarse-limbed species adapted for a forest life may be known as *E. robustus*, the slender-limbed species with

an Arab-like head may be known as *E. gracilis*—a species which eventually gave rise to two varieties, now represented by the Celtic pony and the modified descendants of the race which once flourished on the Libyan plateau. The Celtic pony and horses of the forest (*E. robustus*) type lived in Britain during the Bronze Age, and horses allied to *E. sivalensis* of India and to the wild horse (*E. prejevalskii*), which still survives in Mongolia, reached Britain during, if not before, the 1st century A.D

From Britain or from the Continent the Celtic pony, *i.e.* the northern variety of *E. gracilis*, reached Ireland before the 1st century—evidence of this we have in bones from pre-Christian Irish deposits,—and from the description of Cuchulainn's horses in the Wooing of Emer it may be inferred that horses of the forest variety (*i e. horses with 'feet broad-hoofed and the mane and tail long and curly'*) reached Ireland about the beginning of the Christian era.

Later, large coarse-headed mixed breeds found their way to Ireland, and as they spread greatly modified or completely displaced the original small indigenous races.

The swamping of the small indigenous Irish horses during recent years has been so complete that it is now impossible to find a typical representative of the broad-browed forest horse, and a diligent search has only enabled the writer to discover three ponies presenting the points of slender-limbed Arab-like Celtic variety Of the three ponies belonging to the ancient Celtic race, two were discovered in Connemara, the third was found in Achill Island All three ponies were of a yellow-dun colour, with the head small and narrow, with large eyes and small ears, the neck long, the limbs slender, and the peculiar bunch of hair at the root of the tail which distinguishes the northern or Celtic from the southern or Libyan variety of *E. gracilis*.

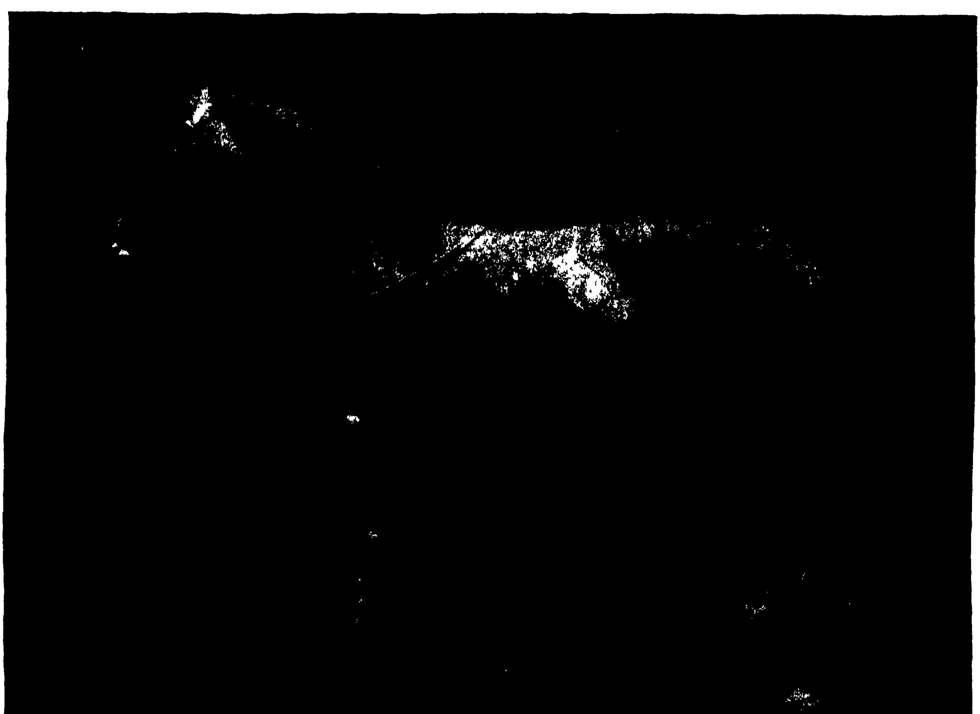
In the Connemara specimens, which measured 12·2 hands at the withers, and 6½ in. below the knee, the head was fine, as in a desert Arab, the ears short, the eyes prominent, the neck and limbs long, and the tail set-on high. The Achill Island Celtic pony, though only 12 hands high, was built on the same lines, but in having a longer neck, a shorter back, and only two of the eight callosities well developed, it probably more closely approached the small, slender-limbed wild race of Auvergne, hunted and figured by our Palæolithic ancestors. The question naturally arises: Why has this small ancient Celtic race of horses all but become extinct in the west of Ireland? Doubtless because in the west of Ireland, as in the western islands of Scotland, changes in the methods of cultivating the soil have necessitated the introduction of larger and more powerful breeds. But even now in Achill Island, notwithstanding the use for some years of stallions measuring from 14 to 15 hands at the withers, the majority of the ponies afford ample evidence of their having in part sprung from the old yellow-dun Celtic race. Evidence of this we have in the fine head and short back, in the slender limbs and tail lock, and more especially in the frequent absence of hind chestnuts and of two or more of the fetlock callosities.

In Connemara, as might have been anticipated, the swamping of the old yellow-dun Celtic stock has been more complete than in Achill Island; nevertheless in the less accessible parts of Connemara one occasionally comes across a pony of the old British type, but their occurrence is very rare.

In addition to a few ponies of the Celtic type measuring from 12 to 12·2 hands, and ponies from 12·2 to 13 hands saturated with Celtic blood, there are Connemara ponies which measure from 13·2 to 14 hands. Some of these large ponies are characterized by long limbs and a short back, others by short limbs and a long back Some of the long-limbed Connemara ponies *closely resemble the better-bred ponies of south* and central Mexico. This resemblance suggests that in the west of Ireland, as in Mexico, some of the ponies are of Spanish origin, and hence related to the Libyan or southern variety of *E gracilis*. A considerable number of the Mexican ponies resemble the finer kinds of Arabs and certain strains of English thoroughbreds in having the ergots small or absent, while a small percentage are devoid of hind chestnuts as well as ergots. The writer has only come across one pure Connemara pony without hind chestnuts; but that the larger Irish ponies have in part descended from a wild variety without hind chestnuts is made evident when intercrossing is resorted to. Of twelve crosses out of Connemara mares by various breeds of stallions, six were devoid of hind chestnuts and of one or more of the ergots It may be mentioned that short-backed Connemara ponies are usually docile, fleet, and great stayers.

The long-backed, short-limbed variety of Connemara ponies (Hobbies) is now regarded by many as including the most typical members of the breed. Evidence of this we have in the description of the Connemara pony given in the Polo and Riding Pony Stud Book. The description is as follows· 'The Connemara pony should be intelligent, active, and enduring, presenting the outline of a long, low, powerful animal covering a lot of ground. The action should be good and straight. The Hobbie should be of a yellow-dun, grey, or bay colour, from thirteen to fourteen hands high, having the croup as high as the withers; the head should be large rather than fine, with large eyes, the ears small and pointed, the distance between the occipital crest and the eyes relatively great, and the distance between the eyes from seven and a half to eight inches. The neck should be strong and of medium length; the shoulders somewhat straight; the withers of moderate height; the body long and deep (girth from 63 to 70 inches), mounted on short stout legs, . . . a good back, powerful loins, slightly drooping rounded quarters, well developed breech, short below the knee, with flat, hard 'bone' (measuring from 6½ to 7½ inches under the knee); and wide, open, well formed hoofs.'—Polo and Riding Pony Stud Book, vol. vii, p. 59.

TYPICAL CONNEMARA PONY WITH FOAL BY AN ARAB HORSE



DALES PONY STALLION—"BLOOMING HEATHER"

A yellow-dun 14-hands mare of this type (see Plate), brought some years ago from Connemara by the writer, proved excellent in saddle and harness, and her offspring, pure and cross-bred, have all been extremely good. Mares of this variety bred with carefully selected thoroughbred stallions often produce light-weight hunters, and they serve as excellent foundation stock for the breeding of polo ponies.

The long, low, broad-browed Connemara ponies are mainly a blend of the short-limbed forest race (*E. robustus*) and of the Celtic and Libyan varieties of *E. gracilis*.

In addition to ponies with an Arab-like head there are Roman-nosed Connemara ponies with a marked prominence between the eyes, such as one sees in certain strains of the English race-horse. Some of the coarse-headed Connemara ponies have high withers and the root of the tail well in front of the point of the buttock, others have low withers and the root of the tail nearly in a line with the point of the buttock. The ponies with the profile markedly convex and the withers unusually high, in all probability mainly belong to the *E. sivalensis* race—a race which played an important part in the making of the English thoroughbred,—while the ponies with the face less bent downwards and somewhat low withers have probably mainly sprung from the race now represented by the wild horse (*E. prejevalskii*) of Mongolia. These large-headed ponies—more especially those belonging to the Prejevalsky type—are often far from being docile and tractable; but, on the other hand, when well cared for in their youth, they often reach a height of 15 hands and develop into excellent hunters. A 15·2-hands horse of this kind, bought out of a herd of Connemara ponies in 1892, was hunted regularly for years during winter and used in a carriage during summer. He was always fit, extremely fast, and a famous jumper, and, as his owner said, 'came out more often than any horse he ever knew'. As a rule the Connemara ponies belong to the riding type, and should hence be invaluable for the breeding of remounts. They are as hardy and as easily kept as Boer ponies, and that they belong to a stout race may be gathered from Dr. Mahaffy's remarks at a recent meeting of the British Association. Dr. Mahaffy said that in the days when there were no railways, if one wanted to send a message to Galway, forty miles away, he put a boy on one of these ponies, away he went, delivered the message, and came straight back, the pony perfectly sound after its eighty miles. During recent years the Connemara ponies have suffered from indiscriminate intercrossing with hackneys, Welsh cobs, and other mixed breeds: but with a little care it would be possible in a few years to form a breed containing all the best traits which a generation ago distinguished the ponies of the west of Ireland. [J. C. E.]

Conops, the name of a genus of handsome two-winged flies, whose larvæ are parasitic upon wasps, humble and other bees. They are somewhat wasplike in form, and are found over flowers. The eggs are laid upon wasps and bees when in flight. The young larvæ burrow into the abdominal cavity of the host, and remain there until ready to transform into the mature flies, which escape from between the abdominal rings of the host. They remain in the body of the host during the winter. Curtis says one species pursues the drone of the hive bee and lays its eggs on it. [F. V. T.]

Consanguinity, blood relationship, more particularly as here understood, close blood relationship, the result of inbreeding. The pairing of nearly related animals for successive generations is often practised, especially when an attempt is being made to 'fix' some desirable new variation, and the history of some of the most successful breeds includes a period of very intimate consanguinity. Close in-and-in breeding is resorted to in order to avoid the risk of 'swamping' the new variation by the introduction of more distantly related blood, and, though it seems probable that the breeder's fears on this score are usually exaggerated, there is no doubt that close consanguineous unions tend to fix characters in a stock, or, in other words, to develop prepotency. But the question of great practical importance is: how far the close in-and-in breeding can be carried without injurious results. The general opinion is that there are definite limits to wholesome consanguinity, and that in-and-in breeding pursued beyond these tends to loss of constitutional vigour, to diminution of size and fertility, and sometimes to malformations and other injurious results. Darwin expressed this general belief when he wrote 'The crossing of animals and plants which are not closely related to each other is highly beneficial, or even necessary, and interbreeding prolonged during many generations is highly injurious'. On the other hand, it must be noted that exact experiments on this question are few and far between, that close inbreeding is not uncommon in nature in isolated and restricted areas, that some hermaphrodite animals (earthworms, snails, &c.) are habitually autogamous (*i.e.* their ova are fertilized by their own sperms). Moreover, although evil effects sometimes follow prolonged consanguineous pairing in the artificial conditions of stock-breeding, it must not be hastily inferred that these evil effects are always due to the consanguinity. There may be a persistence of external conditions of an unhealthy sort which have a cumulative effect as generation succeeds generation, or there may be some organic taint in the early members of the stock which becomes aggravated by the inbreeding just as a desirable organic peculiarity may be enhanced. It has also been pointed out that some animals show bad effects of close inbreeding more rapidly and more markedly than others. Thus pigs are said to be more sensitive in this respect than cattle. In this connection it would be interesting to enquire experimentally whether those animals that are related to gregarious wild races have wider limits of wholesome consanguinity than those whose wild relatives live alone. Just as the tapeworm is accustomed to self-fertilization, so gregarious animals may be more suited for in-and-in breeding than non-gregarious types are.

Professor Weismann bred mice in-and-in for

twenty-nine generations, and von Guaita continued the experiment for seven more generations; as a result, the fertility was reduced by about 30 per cent. Ritzema-Bos bred rats in-and-in for four years, which included a score of generations, and there was no reduction of fertility. After the twentieth generation there was a very marked decrease of fertility, an increase in the death rate, and a decrease in size. But there was no disease or abnormality such as has been observed by some other experimenters. The careful experiments made by Castle on the Pomace-fly (*Drosophila ampelophila*) showed that prolonged inbreeding slightly increased productivity. There is great need for extended experiments in reference to consanguinity.

As it is practically difficult to make sure of an untainted stock, and as the conditions of stock-breeding are always in some measure unnatural, there is much to be said for the prejudice against too prolonged in-and-in breeding, and for the maxim of 'line-breeding'—'Breed the best to the best along the same 'line' of descent, but avoid too close consanguinity'. See BREEDING, CROSSBREEDING, HEREDITY, HYBRIDIZATION; Darwin, Animals and Plants under Domestication, chap. xvii; von Guaita, Berichte Naturforsch. Gesellschaft Freiburg i. Br. x, 1898; Ritzema-Bos, Biologisches Centralblatt, xiv, 1894; Castle, Proc. Amer. Acad. Arts and Sciences, xli, 1906. [J. A. T.]

Conservatory.—A glass-roof structure, usually of some architectural design and furnished with various plants, is known as a conservatory to distinguish it from the plain span-roofed structure styled a greenhouse. Most conservatories are designed for effect rather than to provide suitable accommodation for growing plants, and as a consequence their contents do not as a rule enjoy good health. The best form of structure is one in which there is the maximum amount of light, and a floor of loose gravel instead of a stone or tile pavement. [W. W.]

Constipation. See FÆCES, RETENTION OF.

Consumption. See TUBERCULOSIS.

Contagious Diseases.—Disease brought about by actual contact, as when the virus of rabies is introduced into the blood by a puncture or bite, was formerly distinguished from such maladies as might be incurred by breathing an atmosphere infected by germs capable of being carried by water and deposited upon the susceptible membranes through the medium of the air. Modern pathologists have ceased to make these distinctions, and employ the term 'infectious' as covering both. See art. INFECTIOUS DISEASES. [H. L.]

Contagious Diseases (Animals) Acts. See DISEASES OF ANIMALS ACTS.

Contours.—In the technical language of the field engineer and the surveyor, contours are lines laid down on maps or plans to represent the parts of the surface which are at the same level.

On the 6-in.-to-the-mile and the 1-in.-to-the-mile Ordnance Survey maps issued by our Government, contour lines are laid down. On these maps the figures quoted for the respective contour lines are in relation to the approximate mean level of the sea at Liverpool. The latter is taken as the basis with which to compare all other points the relative heights of which it is desirable to refer to. These contour lines are of immense benefit both to the civil engineer and the estate manager. With them to refer to, one or other can decide on the feasibility of proposed schemes, whether railways, roads, sewage schemes, or water supplies be in the wind, without being put to the expense of preliminary survey.

The altitudes of numerous other points of the surface of the country, apart from the contours, are given in figures on the majority of the Ordnance Survey maps, in the 6.-in. and the 1-in. series among the others. Reference to these figures will be found under LEVELLING. [R. H.]

Contracts.—A mutual contract is the reciprocal undertaking of two or more persons whereby each obtains some right or incurs some liability recognized by law. But the law does not recognize as a ground of action any obligation which is derived from an illegal or immoral contract. Thus gaming and wagering contracts are illegal by statute, while, at common law, agreements to commit a crime or to compound a felony, agreements which are contrary to good morals or against the policy of the domestic relations—*e.g.* imposing a restraint on marriage—are void. All restraints on the liberty of the person, if absolutely unqualified, are void; but contracts for service during a stated time, and restraint in the exercise of a trade, if natural and not unreasonable in the circumstances of the case, are enforceable.

The first requisite of a valid contract is that the parties have deliberately given their consent to it. This excludes incapacity by nonage, unsoundness of mind, or intoxication on the one hand, and of error, duress or force, and fraud on the other.

1. NONAGE.—In England a contract entered into by an infant, *i.e.* a person under the age of 21, is, except in the case of necessaries, absolutely void. In Scotland a male child under 14 or a female under 12 is incapable of consent, and so cannot be bound by any contract; but if the contract be for the advantage of the pupil the other party may be held to it. Minors, that is children between the age of 12 and 14 respectively and 21, are not regarded as incapable of consent, but are entitled to have contracts entered into by them reduced within four years after attainment of majority, on proof of their having sustained a definite and considerable loss. But a minor who has engaged in trade or has represented himself of full age so as to deceive the other contracting party, will be held bound by the contract. Moreover, as in England, if the goods supplied were 'necessaries' the cost of them may be recovered. In Scotland it is only requisite to prove that the goods were 'necessaries'; but in England it must be further shown that they were actually necessary at the time when they were supplied, the fact that the infant was adequately supplied at the time of the additional supply being thus a material point.

2. Unsoundness of Mind, or Intoxication.—A contract by a person of unsound mind is not voidable at his instance unless it can be proved that at the time of making the contract he was incapable of understanding what he was doing, and that his mental incapacity was known to the other contracting party. If a person, who is so completely intoxicated as not to know what he is doing, enters into a contract, it is not void *ab initio*, but is voidable on his regaining his senses. If ratified in any way after he has become sober, the contract will be binding on him.

3. Married Women.—Prior to the passing of the Married Women's Property Acts, the general rule of law was that a married woman's personal obligations were of no avail. To this general rule there were exceptions at common law, while statute has further modified this restriction. Without attempting to go into the details of the various Acts, it may be stated generally that in respect of all property held by a woman married subsequent to 1st January, 1883, in England (July, 1881, in Scotland), she has sole right to such separate estate, the income of which is to be paid to her on her own receipt. With respect to such separate estate, therefore, she may enter into contracts and render herself liable thereupon as if she were unmarried, but in Scotland at all events she cannot dispose of the capital without the husband's consent. Obligations entered into by a married woman who is engaged in trade on her own account are binding on her separate estate. Moreover, where a married woman is living apart from her husband, or where the latter is imprisoned or civilly dead, she may competently enter into contracts which will be binding upon her.

4. Error is not in itself a ground for voiding a contract, but it may have this effect if it be error in essentials; as, for example, as to the identity of the person with whom the contract is made, or of the thing which is the subject-matter of the contract. In such cases there has never been a real consent by both parties. Further, a party who has entered into a contract through error may rescind the contract if he prove (1) that but for the error he would not have contracted, (2) that the error is one of fact and not of law, and (3) that the error was induced by the representations of the other party or his agent made in the course of the contract. 'If his error is proved to have been so induced, the fact that the misleading representations were made in good faith offers no defence against the remedy of recission.'

5 Duress, force, or fear, when such as to intimidate a mind of ordinary firmness, may be good ground for annulling a contract. But the mere threat of legal action, or the fear of the legal consequences of refusing the request, would not constitute sufficient grounds for voiding the contract. Undue influence may also be a good ground of reduction. But as a rule the relative position of the parties to the contract will at best merely raise a presumption of unfairness. To justify a reduction there must not only be inadequacy of consideration, but also on the one hand a subjection to a dominant influence, and on the other an abuse of confidence.

6. Fraud may invalidate a contract. If a party to a contract make false representations of material facts either deliberately or with reckless ignorance, and with the intention that they be acted upon by the other party so as to deceive him, the contract may be annulled, unless a third party has meantime, in good faith and for value received, acquired rights under the contract.

A contract may as a general rule be constituted by admission, the evidence of witnesses, or by writing. But there are many contracts which are not obligatory unless reduced to writing, as, for example, those dealing with the sale of land, or leases for more than three years in England or more than one year in Scotland.

A mutual contract being a bilateral deed presupposes some consideration, though not necessarily an adequate one, and in England the consideration must be present or future. A gratuitous promise, unless when made by deed, is not binding in England, but in Scotland consideration is not essential to a unilateral obligation whether written or verbal.

A contract is usually constituted by an offer and the acceptance thereof. In England an offer being without consideration may—unless made by deed—be revoked at any time before acceptance, even if the offerer has promised to keep it open for a certain time, but in Scotland it is a question in each case whether or not the offer binds the offerer for a definite time. If it does not, he may recall it at any time before acceptance; but if it does, he is bound by his offer up to the time limit. The acceptance, if express, must precisely meet the offer, for if any new condition is introduced this is not an acceptance but a counter offer. The acceptance completes the contract if it be despatched before the receipt of notice of withdrawal, or before the time limit, if such has been fixed, has expired. Where an offer has been made by post, the posting of an acceptance completes the contract even although the offerer withdraw the offer after the posting, but before the acceptance has had time to reach him. The reason for this is, that the post office is regarded as the agent of the offerer, and delivery of the acceptance to the post office is delivery to the offerer, who cannot thereafter revoke.

Contracts may be discharged by performance or by agreement of the parties. They may be discharged by breach, whereupon the right to claim damages will ordinarily arise to the party not in breach. In some cases impossibility of performance will discharge a contract. Thus where the subject of the contract is some specific thing whose existence is essential, its extinction without fault on the part of either party will discharge the contract. In the same way, the death of a party who has contracted to give personal services brings the agreement to an end. As a general rule, however, practical impossibility of performance, as, for example, extreme cost or difficulty, is no excuse for not carrying out a contract. [D. B.]

Contusion. See Bruises.

Convallaria.—The Lily of the Valley (*Convallaria majalis*), a native of England and Europe and Northern Asia generally, is a favourite garden plant. It is largely grown for forcing, especially in Germany, where hundreds of acres are devoted to the production of the roots, which are lifted and exported in bundles in midwinter. By a process of retarding, these roots can be stored and kept dormant, so that they may be forced into flower at any time of the year. The plant grows best in a light sandy soil, although it is happy enough in almost any position in the garden, where it blooms naturally in May. There is a double-flowered variety and also one with pink flowers. [W. W.]

Convolvulus, a genus of annual or perennial herbs with twining stems and showy, funnel-shaped flowers. The British species, although often troublesome weeds, are handsome; *C. arvensis*, the farmer's pest, having creeping stems, and white or pink flowers; *C. sepium* is the common Bindweed of the hedgerows, and has large white flowers; *C. Soldanella*, which grows on the sand dunes, has trailing kidney-shaped leaves and bright-pink striped flowers. Other species which are grown in gardens are *C. mauritanicus*, a blue-flowered trailer, and *C. tricolor*, an annual with silky leaves and large three-coloured flowers. See also IPOMŒA and BINDWEEDS. [W. W.]

Cony, or **Coney,** a name properly belonging to the rabbit but more frequently applied to the Hyrax, which is referred to under this name in the Old Testament. In external form and in habits the Syrian Hyrax bears a certain resemblance to the rodents, but its real affinities are with the Ungulates, and its nearest relative is the elephant. It is rather smaller than a rabbit, is of a tawny red colour, with rounded head, pointed muzzle, short weak legs, and short tail. It inhabits rocky heights, gorges, watercourses, and the like, and does not burrow, but lines a nest in a hole in the rocks for its young. Its feet are soft and elastic, and are covered with rough furrowed skin, which acts as a sucker, and enables it to walk up and down the face of an almost perpendicular rock with ease. The conies live in companies, set sentinels, and never venture far from their holes. They feed on grass and mountain plants, and can subsist for a long time with no water save dew. They are so well adapted to their rocky home that, notwithstanding their defencelessness, they remain fairly abundant in suitable localities. [J. A. T.]

Cooley Creamer.—This system of cream raising obtained a wide popularity in America prior to the advent of the separator. It is one of the neatest and handiest of the many creamers that came into vogue in the earlier portion of last quarter of the 19th century. It was nothing new in itself, but an adaptation of some other and somewhat improved. Shallow pans for milk rested on a framework which was arranged to accommodate a continuous flow of cold water underneath and touching the milk pans. This application of cold water to pans containing milk expedited the rising of cream on that milk. An English creamer, practically identical in main points with the Cooley, was the Jersey Creamer. It was in all essentials an anglicized and improved Cooley, and for some years enjoyed a deserved reputation in England. It may be concluded, however, that all creamers, so-called, are doomed to eventual disappearance from the tracks which the separator is making. The separator wins because it separates cream from milk at once, if need be, when it comes into the dairy, and does away with milk pans and creamers in a wholesale fashion, leaving the dairy unoccupied by impedimenta which can now be dispensed with as useless superfluities. [J. P. S.]

Coomb, a corn measure having a capacity of 4 bushels.

Co-operation.—As long ago as 1864 Mr. Gladstone said that there was 'no greater social marvel' than the way in which the co-operative societies of the towns had flourished At the present time the retail co-operative societies make an annual profit of some ten millions sterling. The co-operative manufacturing societies produce more than eight million pounds' worth of articles in a year, £3,360,000 being in respect of corn milling, £625,000 of baking, and £1,000,000 of boot, shoe, and general leather goods. The Manchester Co-operative Wholesale Society manufactures its own bacon, jams, tobacco, and cocoa, and believes that it will soon be the largest miller in England. It looks forward to the time when a large proportion of the £6,000,000 of goods, largely foods, imported from abroad under co-operative auspices shall be produced at home. The turnover of the town co-operative movement, which was only inaugurated two years before the repeal of the Corn Laws, exceeds £100,000,000 per annum.

Compared with urban co-operation, agricultural co-operation is quite a new thing. A score of years ago there was not a central agricultural organization society in the three kingdoms. Now there is one in each. The oldest, founded by Sir Horace Plunkett, is the Irish Agricultural Organization Society (22 Lincoln Place, Dublin). As a result of its labours there are now the following co-operative societies in Ireland:—

Creameries	331
Agricultural societies	151
Credit societies	232
Poultry societies	25
Flax societies	9
Industries societies	50
Beekeepers' societies	18
Bacon-curing societies	7
Miscellaneous societies	13
Federations	4

The annual turnover is something like two millions. It is claimed that co-operation has cut down the prices of artificial manures from 20 to 40 per cent. 'The wiseacres scoffed at our 'toy banks',' writes Mr. R. A. Anderson, secretary of the Irish Agricultural Organization Society, 'but, in spite of sneers, our capitalization of honesty remains the one most valuable asset.' The 'greatest effect' of the co-operative movement, he says, is that 'it has taught our people to think; it has made them self-reliant, business-

like, and industrious'. The little banks have advanced not far short of a quarter of a million without loss. The 'gombeen man' or village universal provider no longer has all the countryside in his hands. Tattered peasants at co-operative meetings may be found expressing themselves in decimal points, and calculating the value of soluble phosphates at so much per unit. Political and religious barriers have also been broken down in a wonderful way by co-operative activity. There is no question, on the part of any impartial enquirer, as to the vast amount of good which has been done economically and from a social point of view. Co-operation, by offering men capital, seeds, implements, and manures at reasonable prices, by practical methods of marketing, by interesting people of one part of the country in the doings of other parts, and generally by widening the popular outlook, has prepared the way for taking the utmost advantage of the new land legislation, which gives such a remarkable opportunity to small holders.

In England, where a leading spirit of agricultural organization has been Mr. R. A. Yerburgh, the British Agricultural Organization Society, combining with the National Agricultural Union in 1901, became the Agricultural Organization Society (Dacre House, Dacre Street, Westminster, London, S.W.; secretary, Mr. J. Nugent Harris). The following societies are now affiliated:—

Societies for supply of requirements and sale of produce	118
Dairy, bottled milk, and cheesemaking societies	13
Rural industries societies	3
Allotments and small holdings societies	26
Agricultural credit societies	15
Auction markets	2
Fruit-grading societies	2
Motor service societies	2
Co-operative farming societies	2
Agricultural Co-operative Federation, Ltd.	1
entral Co-operative Agricultural Bank, Ltd.	1
	185

The rate of growth may be thus indicated: 1900, 12 societies; 1901, 25 societies; 1902, 41 societies; 1903, 72 societies; 1904, 98 societies; 1905, 123 societies. Represented in four counties in 1901, co-operation had societies in forty by 1905. The turnover grew from £9467 in 1901 to half a million in 1907. There are now in membership 10,000 out of the 224,000 farmers in the country.

The largest of the societies affiliated to the Agricultural Organization Society is the Eastern Counties Farmers' Co-operative Association (Ipswich), established in 1904. Its sales, which in 1905 amounted to £50,000, were in 1907 some £177,000. The called-up capital is less than £1000. The 686 members farm an average of 309 ac., a striking argument in reply to those who suggest that co-operation has nothing to offer the large farmer. In point of fact, it was the larger rather than the smaller farmers who were the first to come forward to join the co-operative movement in East Anglia. The work of the association, which is affiliated to the Co-operative Wholesale Society as well as to the Agricultural Organization Society, is managed by a trading committee of farmers with a competent staff. The association's pig ledger shows an average total of £4000 a month. The organization has a pig buyer who visits the pig markets all over the country, protects in a notable way the members' interests against 'rings', and provides expert advice as to feeding and the requirements of the market. The average profit aimed at by the association in its transactions is 2½ per cent, which has been found to be sufficient to cover all working expenses and interest on share capital, and to allow a substantial sum to be placed to reserve. On cakes and feedingstuffs the commission is less than 2½ per cent. In one year the members bought more than 12,000 sacks of maize, nearly 5000 tons of coal, and 25 tons of binder twine Some 500 sacks of clover seed were sold at prices in many cases from 5*s.* to 6*s.* a bushel above what would have been obtainable through the ordinary channels. More than 10,000 sacks of corn were sold for members at Mark Lane. A cargo of beans was shipped to the north of England at 4*s.* a sack above local prices. The value of the pigs sold was £48,870 The association supplies its members with everything they need, from implements, engines, bicycles, coal, and lubricants, to milk carts, manures, fencing, barometers, and paint. Local trading committees are formed in suitable districts. Very few firms now refuse to supply the association. The Eastern Counties Dairy Farmers' Co-operative Association (depot, Stratford, London, E.) was established in 1896 as an offshoot of the Eastern Counties Dairy Farmers' Association. It works by means of half-yearly contracts with its members on the one hand, and with the retailers on the other. In 1907 the turnover in milk was £35,750. In addition to this, £594 represented sales of eggs, butter, and poultry; £172 sales of utensils; and £7371 sales of manures and feedingstuffs. A margin of 10 per cent in regard to quantity is allowed to members in supplying milk under their contracts. The milk which does not go direct to the association's customers is handled, according to the state of the market, at Stratford, where refrigerating, pasteurizing, and separating apparatus is provided. Milk which, at the time of the foundation of the association, would have sold at 1*s.* 7*d.* per barn gallon in the winter months and 1*s.* 2*d.* in the summer months, now sells for 1*s.* 8*d.* and 1*s.* 4*d.* Some of the association's milk is sold to industrial co-operative societies at Woolwich and Stratford.

The Carmarthen Farmers' Co-operative Society has in four years obtained a membership of 600, and has a turnover of £27,000. The society claims to have obtained for its members reductions of 10 to 15 per cent in feedingstuffs, of 20 to 30 per cent in seeds, and of 30 to 40 per cent in artificials. The Farnham, Alton, and District Co-operative Association states that the reductions effected by its agency averaged 20 per cent on linseed cake, 5 per cent on superphos-

phate, basic slag, and kainit, and about 7½ per cent on wire. The Newport (Salop) Society has had a depot erected for it by the Great Western Railway. The Dulas Co-operative Society, one of the smaller organizations, states that it gets coal and slag 6*s.* a ton cheaper than its members used previously to do. The Darley Farmers', another small society, notes a saving of 5*s.* a ton on cake. The Winchcomb Co-operative Auction Mart has turned over £18,000 at its sales in less than three years. The Framlingham Society sold in twelve months more than a million and a half of eggs at prices 25 per cent better than were formerly paid by the higgler. This society has now opened branches. In different parts of the kingdom successful co-operative dairy societies are in existence. The Nidderdale Society supplied £7000 worth of milk, &c., to the town of Harrogate. Some of it is sold from house to house, and some from a shop. The Newark Dairy is a co-operative factory for the sterilization and bottling of milk to be sold in Newark and Grantham. More than 13,000 gal. are disposed of in a year. The Forest Supply Association handles nearly 21,000 gal. of milk, disposing of it at its own shops. The Scalford Dairy makes a specialty of cheese. The Brandsby Motor Service was established by the North-Eastern Railway Company at the instance of the Brandsby Agricultural Trading Association, and has two sets of premises. Goods are carried at 3*s.* 6*d.* per ton, whereas the carriers used to charge 5*s.* a ton. There has been such a development of traffic that a light railway may have to be built. One of the advantages of the service has been the increased utilization of lime on the land. The organization now takes all the gas lime York gasworks can supply. At the instance of the Teme Valley Agricultural Association the Great Western Railway Company has established a similar motor service in the Teme Valley. The traffic has proved larger than was anticipated, and the service has been highly satisfactory to the company and to the farmers.

The Agricultural Organization Society has established a trading federation of agricultural co-operative societies. About sixty societies are now federated to this Agricultural Co-operative Federation (124–7 Minories, London, E.C.).

The Agricultural Banks Association, founded in 1893, was in 1903 amalgamated with the Agricultural Organization Society, and there are now fourteen agricultural credit societies, and a Central Co-operative Agricultural Bank, Ltd. The oldest credit society is that of Scawby. In ten years it lent out £1032 in thirty-eight loans. No losses have been made.

During 1908 the Agricultural Organization Society was instrumental in founding a co-operative insurance company for agricultural live and dead stock.

The Agricultural Organization Society issues the Agricultural Organization Society Journal, 6*d.* monthly.

Mention should also be made of the Journal of the National Poultry Organization Society (12 Hanover Square, London, W.C.), 6*d.* monthly. More than four million eggs were sold at the forty depots of the society in a year. This is equivalent to a weight of 240 tons, and a value of about £17,000. The society could dispose of much larger supplies if they were forthcoming. The Street, Somerset, branch sells some three million eggs a year, and has shown a satisfactory profit for sever? years. The Fairford depot reports that since its establishment local prices have risen 30 per cent.

The Scottish Agricultural Organization Society (5 St. Andrew Square, Edinburgh) had established by the end of 1907, as the result of two years' work, seventeen co-operative societies; three are co-operative dairies. In 1907 the Scottish Agricultural Organization Society took over by arrangement the work in Scotland of the National Poultry Organization Society. The Rowallan Co-operative Dairy Association handles '1200 gal. of milk per day, paid for at a price higher than that given to farmers outside the association'. The pioneer society in the Orkneys has forced the egg merchants to raise prices On eggs alone at least £600 more has been paid to the crofters than they would have received but for the society's efforts. The total gain to the crofters at Eday since the society was started cannot be less than £800. It has been obtained on a capital of £13, 5*s.*

The most remarkable development of Agricultural Co-operation has taken place abroad. An account of this is given in Mr. Pratt's Organization of Agriculture (Murray), but we are able to supply some later figures. There is a co-operative dairy in almost every parish in Denmark—the number is 1101—and 36 co-operative bacon factories. The success of the Danish trade in eggs, as indeed of the trade in eggs in every Continental country, is due to co-operative methods. The eight Danish societies exported 14,000,000 eggs in 1907. In Denmark there are even 60 beekeepers' societies. There are also thriving live-stock insurance co-operative organizations; one has 7000 members. Mr. Pratt states that it is not unusual for a Danish farmer to belong to ten local co-operative societies. There are, of course, societies for the supply of agricultural necessities—973 of them—as well as for the sale of produce. In Germany the value of the purchases of agricultural necessaries by the German Credit Bank has been put at £4,000,000. In 1903 there were more than 17,000 co-operative societies in the German empire. In France and Belgium the success which has been obtained by co-operative methods is remarkable. In Belgium, in particular, there is an incredible number of societies for all sorts of purposes. Co-operation has also made considerable advance in Italy. As far as Holland is concerned it is only necessary to go over to the Hook to see in the Westland how largely by co-operation the small farmers are able, in spite of heavy rents and heavy wages, to sell and buy on lines which enable them to compete in the London market. The reader may be reminded that these Dutch growers cannot be considered to have any advantage which might be derivable from tariffs, as Holland is practically a free-trading country. The immense development of agriculture in

Hungary, illustrated at the exhibition in London, is largely due to intelligent co-operation. Co-operation is also at work in Finland, in Siberia, and in Sweden and Norway.

In the light of what has been accomplished at home and abroad during the last few years, it is impossible to doubt that, in the case of small farmers, a great deal is to be gained by wisely directed co-operative effort. The chief hope of the small holders, who are increasing in numbers in England as in Ireland under recent legislation, lies in co-operation. In the case of farmers on a larger scale the advantages are not so obvious at first sight. It seems to be the case, however, that in many instances even men possessed of a fair amount of capital frequently fail to obtain the low prices and the value in point of quality which skilful co-operation could give them in the matter of seeds, feedingstuffs, and manures. The farmer has to cope not only with high prices of necessaries, but with supplies which are not always what they seem to be. The trade in manures has been described to the writer by an inspector of the Board of Agriculture as a 'very friendly trade'. The meaning was that credit was easy, and the connection between the parties lasted for many years. There can be no doubt, however, that inferior manures, feedingstuffs, and seeds are sold when analysis by the customer is known to be unusual. What prevents many farmers co-operating is that the merchants who buy their corn expect to sell them artificials and feedingstuffs. The experience of the co-operative society at Ipswich seems to show beyond doubt that large farmers are able to buy on their own account with immense advantage. Obviously, much care and experience is needed in the choice of the officials who are to carry out the transactions of co-operators. They must possess not only great business ability, but long experience of the implement, feedingstuffs, and artificials trade. The facts at the command of the Agricultural Organization Society show that the difficulties are not insurmountable. The student of rural industry cannot fail to have taken note of the closer organization of the trades with which the farmer deals. They are not only more closely organized, but take advantage of the very latest business methods. It stands to reason that in dealing with merchants with an up-to-date commercial organization behind them, farmers who go on buying and selling very much on the same methods as suited the circumstances of their forbears must be at a disadvantage. The work of the Agricultural Organization Society has merited the approbation it has received from successive Ministers of Agriculture, and no surprise was expressed when the government subsidy was announced. The progress in the adoption of co-operative methods may be slow, but that substantial advances will be made in the next few years can hardly be questioned. Much is hoped for from the recent formation by the English and Scottish Societies of a Joint Board for Trade. (A joint board for propagandist work has also been established.) The sale of produce is plainly a more difficult form of agricultural co-operation than the purchase of requirements, but, as has been seen, a notable beginning has been made. As the various societies increase, the number of trading federations will also grow. For some time past the urban industrial co-operative movement has seemed rather at a standstill. In some districts—in London, for example—little has been done. One of the most interesting developments of the future will no doubt be the closer association of rural co-operative production with urban co-operative consumption. But even if this be delayed, the evidence unquestionably goes to prove that rural co-operation must prove of marked service to agricultural industry, and that the public men who in England and Ireland have given so unselfishly of their time and means to forward it, have deserved well of the country interest. Co-operation cannot proceed in this country exactly on the lines which have been followed on the Continent. Our conditions are admittedly different; but that co-operation by methods adapted to our peculiar conditions has potentialities of usefulness within certain limits there can be no doubt whatever. [J. W. R. S.]

Copper Compounds. — Compounds of copper destroy fungi or prevent the germination of their spores, and form our most important fungicides. They combine with and coagulate albumen to form non-putrescible substances, and therefore act as preservatives and antiseptics. When consumed in more than very small quantities they are poisonous to man and the higher animals. Soluble compounds of copper readily destroy the foliage of certain plants, and are therefore used as weed killers, especially for weeds of the cruciferous family. Compounds of copper are also used as insecticides, as agents for fixing the green colour of certain foods, and for a great variety of other purposes.

The best-known compound of copper is the sulphate, $CuSO_4 5H_2O$, which is popularly known as blue vitriol or bluestone. Other soluble salts of copper which are sometimes used are the chloride and the acetate. Copper sulphate itself and preparations made from it are very extensively used in combating the ravages of fungi. Timber is preserved from the fungus which causes dry rot by treating it with a solution of copper sulphate. So the spores of fungi, such as those of smut, are destroyed in wheat and other cereals by steeping the seed corn in a solution of this salt. The most generally used of all fungicides is prepared from copper sulphate and lime, and is known as Bordeaux mixture. A number of different modifications of this preparation are used, but the most common form is obtained by dissolving 12 lb. of copper sulphate in water, and adding to this a cream made by slaking 6 lb. of good lime, mixing this with water, and straining through a fine sieve to remove all grit. The whole mixture is then made up to 100 gal. It is essential that the lime should precipitate all the copper so that no copper remains in solution. If copper is left in solution it may injure the foliage of plants. Frequently treacle is added to the preparation. This makes it adhere better to the foliage, and such a mixture is more effective. Bordeaux mix-

ture is best known in this country as a preventive of potato disease. It is also used against the fungoid diseases of many fruit trees, and of garden, kitchen garden, and agricultural plants. Very often when used in fruit culture it is combined with an insecticide such as Paris green. Bordeaux mixture is a preventive rather than a cure for fungoid diseases, and should therefore be applied before the disease attacks the crop (see FUNGICIDES, and POTATO, FUNGOID DISEASES).

The chief copper compound used as an insecticide is the aceto-arsenite, or Paris green (see ARSENIC COMPOUNDS). During recent years a solution of copper sulphate has been extensively used to destroy the common weed variously known as charlock, skelloch, yellow weed, wild mustard, or runch. If this very troublesome weed is sprayed with a solution of copper sulphate of about 3 or 4 per cent strength it is destroyed or seriously injured. At the same time, corn crops among which the weed may be growing are not seriously damaged, and even clover plants are not permanently harmed. The solution in common use is made by dissolving 3 to 4 lb. of blue vitriol in 10 gal. of water. This is applied in spray at the rate of about 40 gal. per acre when the weed is still quite young, say about 3 in. high A second spraying is sometimes given after an interval of about a fortnight.

Solutions of copper sulphate should always be made up in wooden or earthenware vessels. They should on no account be made or kept in iron or zinc vessels, as the copper salt attacks the iron or zinc and deposits copper.

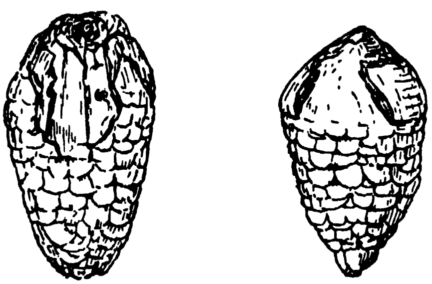
The chief impurity of copper sulphate is iron sulphate or green vitriol, and sometimes the more expensive copper sulphate is heavily adulterated with this cheap iron compound. Purchasers of copper sulphate should be careful to obtain a guarantee that it is of 98-per-cent purity, and it would be well if the purity of this substance was checked occasionally by analysis.

The colour of preserved green peas, French beans, and other preserved green vegetables is often due to the addition of copper sulphate, which gives them a permanent bright-green colour. Preserved vegetables which have not been 'greened' with copper are naturally pale and dull in colour, but are generally much superior in flavour to the 'greened' article. As copper compounds are poisonous, their use for this purpose is reprehensible, and the Departmental Committee on Preservatives and Colouring Matters in Foods recommended that the greening of preserved vegetables with copper should be prohibited. [J. H.]

Coppice is the term applied to woods that are cut down more or less regularly at recurring short periods of years and then allowed to reproduce themselves by throwing out shoots from the stools left in the ground. The legal term for coppice wood is *sylva cædua*, and at law an owner in possession of an entailed estate obtains the entire income from the coppices cut in the ordinary course of estate management; whereas in England the timber or highwood (*saltus*) is mainly treated as capital, and he obtains only the interest on its investment, though in Scotland an heir in possession under an entail is entitled to cut the timber, as well as the *sylva cædua*, as long as his possession lasts. Coppices, and particularly the copsewoods consisting of coppice under standards, *i.e.* a low coppice underwood growing below tall standard timber trees, is the national form of English forestry imposed upon landowners by the Statute of Woods in 1543 and subsequent Acts (see ACTS OF PARLIAMENT). In former times the coppices and copsewoods were among the most profitable portions of large estates; but during the last fifty years, and particularly in the last twenty to thirty, which have witnessed the decay of the once very profitable oak-bark industry for tanning, and the cessation of any large demand for hop-poles, hurdles, &c., the market for small wood has become greatly reduced, while the destruction caused in many places by rabbits has made coppicing hardly worth while. Among coppice woods, oak, ash, hazel, and sweet chestnut have always been the most favoured species; but most underwoods consist of a mixture of hard and soft woods, oak, ash, hazel, chestnut, lime, maple and sycamore, beech, hornbeam, willow, birch, alder, aspen, &c., and shrubs like holly, buckthorn, and dogwood, which were habitually coppiced or cut over at periodic intervals varying locally from 8 or 10 to 20 or 25 years of age. For oak-bark, pure coppices worked with a rotation of 14 to 16 years generally gave the best results; while for ash a rotation of 12 to 15 years, and for hazel and chestnut about 7 to 10 years, usually produced the most useful and profitable classes of poles, rods, and withes But the decay in the coppice industry has during the last fifty years become so marked, that this once flourishing branch of estate forestry in England has become almost a lost art. Where still profitable the rotation of course, as formerly, depends not merely and mainly on the local market available, but also nowadays very much on the owner's personal desires as to profit and utility or else game-cover and ornament. And one of the great advantages of copsewoods is that they are not only more beautiful, but also better suited than any other form of woodland for game protection, fox coverts, and sport generally, than any other kind of woodland. The most valuable pure coppices are the osier-holts in the Fen districts (see OSIER), cultivated for basketmaking and forming rather a branch of horticulture than of sylviculture. In coppice-growing it is desirable to keep the stock of material as thick as convenient, which can best be done by plashing or layering side-shoots to fill blank spaces at the time of coppicing; and of course preference should always be given to increase thus, or also by means of planting, the more profitable kinds of wood. Reproduction of stool-shoots and also of suckers in some cases is stimulated by cutting clean and slantingly and as nearly flush with the ground as possible, because rugged stools remain wet and are apt to rot, while tall stools soon get gnarled and exhausted in reproductive capacity. Pure coppices of course yield a finer growth of rods and poles and a larger crop per acre than underwoods in copses; but this loss is usually more than coun-

terbalanced by the growth of the standards or overwood, part of which is removed at each time of coppicing. Thus, say that the fall is made at regular periods of 20 years, and that the oldest trees are allowed to grow till 100 years of age, then there would be four classes of standards, respectively aged 20, 40, 60, and 80 years just after a fall of coppice, and 40, 60, 80, and 100 years just before the next fall, twenty years later. To provide standards the best poles, preferably self-sown saplings, are marked for remaining as stores (heirs, tellers, &c.); and at each fall a certain proportion of these different age classes of standards is cut as timber along with the underwood, so that a normal proportion is maintained. Say there are 2 trees of the oldest class (80 to 100 years) per acre, then there would be perhaps 4 of the 60 to 80 class, 8 of 40 to 60, and 16 of 20 to 40 years; and at each fall 2, 2, 4, and 8 of these would respectively be felled, while 16 new saplings would be stored to maintain the normal proportion. And, of course, in selecting stores the best-grown specimens of the most profitable timber tree on the area (oak and ash for preference) are chosen as standards. [J. N.]

Coprolites.—These objects are the fossil excreta of fishes, reptiles, or other vertebrate



Coprolites, Lower Chalk, Folkstone

animals, and are usually found associated with fossilized bones and nodules of phosphatic material (see art. PHOSPHORITE). The nodules, formed by chemical concretionary action, are sometimes confused with true coprolites. The value of coprolites to agriculturists depends on the amount of calcium phosphate (phosphate of lime) present, which may reach 65 per cent. The material is now usually converted into commercial superphosphate before use upon the land.

Coprolites are usually brown or grey-black on the surface, often with a polished appearance, like that of the nodules and phosphatized fossils associated with them. Coprolites of fishes occur in the 'bone-bed' of Rhætic age, well known at Aust Cliff on the Severn, north of Bristol, and, together with those of marine reptiles, in the Lias of Lyme Regis. The beds with phosphatic nodules in parts of the English Cretaceous strata also yield true coprolites (see numerous references in H. B. Woodward, Geology of England and Wales, 2nd ed., 1887). Coprolites are also said to be responsible for part of the phosphatic beds of Lower Carboniferous age in the region of the Firth of Forth. [G. A. J. C.]

Coprolites were the earliest mineral phosphates used for the manufacture of dissolved manures. The earliest dissolved phosphates were made from bone black, bone ash, and bones themselves about 1840, and soon afterwards dissolved mineral phosphates were prepared by Lawes from ground coprolites. This was the beginning of the mineral superphosphate industry which has since attained such enormous proportions (see ARTIFICIAL MANURES).

Suffolk coprolites were first used, then Cambridge coprolites. Suffolk coprolites are found in tertiary deposits and are very impure. The coprolites found in Bedford and Buckingham are similar in nature, as are also Boulogne coprolites. Cambridge coprolites are found in the Upper Greensand, and are of better quality than Suffolk coprolites. Suffolk coprolites contain 45 to 55 per cent of phosphate of lime (tricalcium phosphate), together with 10 to 20 per cent of carbonate of lime, 7 to 12 per cent of oxides of iron and aluminium, and 10 to 20 per cent of siliceous matters. They also contain small quantities of compounds of magnesia, fluorine, &c. Cambridge coprolites contain 50 to 65 per cent of phosphate of lime, with 10 to 18 per cent of carbonate of lime, 4 to 6 per cent of oxides of iron and aluminium, 5 to 10 per cent of siliceous matters, and a little calcium fluoride and magnesia.

Cambridge coprolites contain considerably less iron and alumina than Suffolk coprolites This was very much in their favour in the manufacture of superphosphate. The presence of considerable quantities of iron and aluminium compounds renders it more difficult to dissolve the phosphates, and renders the superphosphate more liable to revert through the formation of insoluble phosphates of iron and alumina. From the point of view of the manufacturer of superphosphate, therefore, the less iron and alumina a mineral phosphate contains the better (see SUPERPHOSPHATE)

Coprolites continued the principal mineral phosphates used in this country for the manufacture of superphosphate till about 1880 They are found in the form of small hard nodules like pebbles, and are said to have been used at one time for roadmaking. Great areas were dug over for them, and the coprolites riddled out from the surrounding soil. Considerable sums were paid to landowners for the right to extract them from the soil in districts where they occurred, and in many cases the soil was improved at the same time by the process. After 1880 the use of coprolites fell off, owing to the introduction of better and cheaper mineral phosphates, such as Carolina phosphates, Florida phosphates, and, later, Algerian phosphates (see MINERAL PHOSPHATES). Coprolites have now quite passed out of use, and have been entirely replaced by superior phosphates such as those already mentioned. Considerable quantities continued to be used till about 1890.

The term 'coprolites' is sometimes wrongly applied to mineral phosphates as a class, and in those districts where ground mineral phosphate is to a certain extent used as a manure it is very frequently called ground coprolites. This

arises from the fact that agriculturists became familiar with the term 'coprolites' in days when it was practically the only mineral phosphate in use, and continued to apply the term to other mineral phosphates, such as Algerian phosphate, in ignorance of the fact that coprolites had passed out of use and been replaced by other phosphates.

Nearly all the coprolites used were made into mineral superphosphate. They were first ground to a fine powder, and then treated with sulphuric acid in such quantity as would turn the insoluble phosphate into water-soluble phosphate to as great an extent as was consistent with maintaining the finished product in a merchantable condition. If too much acid is used, though the phosphate may be dissolved to a greater extent, the superphosphate is rendered too damp and sticky for use (see SUPERPHOSPHATE). In the water-soluble condition phosphate is more available to plants, and therefore more active as a manure, than in the original insoluble condition of tricalcium phosphate. A great controversy raged at one time around the question of whether it was better to turn coprolites into superphosphate or to use them in the finely ground form. About thirty years ago the orthodox school of agricultural chemists had come to regard ground mineral phosphate as too insoluble to be of use for manurial purposes, and held that it must be turned into superphosphate before it is fit for use as a manure. The experiments of Mr. Thomas Jamieson of the Agricultural Research Association of Aberdeen drew attention to the fact that undissolved mineral phosphates have considerable value and availability as manure if finely ground. For some time the question was fiercely debated. On the one hand, much more was claimed for undissolved phosphates than could be justified, while on the other their value was depreciated to quite as extreme an extent. This controversy has now died down, and it is generally recognized that ground coprolites and other ground mineral phosphates have considerable value and availability as manure, but are slow in action. This slowness of action has prevented their extensive adoption as manure, although per unit they are much the cheapest source of phosphate. On the other hand, soluble phosphate, such as is present in superphosphate, is quick and certain in action, and these properties have continued to cause its general use as manure in spite of certain disadvantages which it possesses, and of the fact that per unit of phosphate it costs about twice as much as ground mineral phosphate. For every ton of coprolites which was used directly as manure, at least 100 tons were used after being made into superphosphate. This continues to be the case with the purer phosphates which have replaced coprolites. The interest of coprolites as manure is now chiefly a historical one. [J. H.]

Copyholds. — Copyhold lands are lands holden by copy of court roll, that is the muniments of the title to such lands are copies of the court roll or book in which an account is kept of the proceedings of the court of the manor to which the lands belong (Williams's Real Property). The steward of the manor has the right to possession of the court roll (*re* Jennings, 1903, 1 Ch. 906). The tenure exists commonly in England (not in Scotland), though enfranchisements under the Copyhold Acts and otherwise have converted a good deal of copyhold into freehold land. It is called a base tenure because the original copyholders were villeins or serfs holding at the will of the lord of the manor, and in return for their land performing agricultural services, such as ploughing, carting, reaping, &c., for the benefit of the lord. The mines and minerals on copyhold land belong to the lord of the manor and not to the copyholder, and he has a right also to all timber, but the lord cannot come upon the lands to open mines or cut timber without the copyholder's consent. A copyholder cannot grant a lease of his land beyond the term of a year without the lord's consent, unless longer leases are (as is often the case) authorized by the special custom of the manor. The incidents of copyhold tenure differ in various manors, and depend upon the customs of the manor. Quit rents of small amount are not unfrequently payable, and fines become payable on death or alienation by the copyhold tenant. By the customs of some manors the fines are arbitrary, but in modern times fines, even when arbitrary by custom, must be reasonable to be enforced, and are restricted to two years' improved value of the land after deducting quit rents (Scriven on Copyholds, 7th ed., p. 182).

Copyhold lands are transferred by surrender and admittance, which are entered by the steward of the manor in the court rolls. Surrenders formerly were made either in court, that is at the customary court of the manor, or, if made out of court, must have been presented by the homage at the next court; but it is now provided that surrenders made out of court shall be entered by the steward on the court rolls (Copyhold Act, 1894, 57 & 58 Vic. c. 46, s. 85).

In some manors the lord has the right on the death of a tenant to seize the best beast or other chattel under the name of a heriot. In order to avoid this inconvenient right copyhold lands are often vested in trustees jointly, and it has been decided that in such a case there will be no right to a heriot on the death of the cestui que trust (Trinity College, Cambridge, *v.* Browne, 1686, 1 Vern. 441).

Copyhold lands may be enfranchised voluntarily by a grant from the lord of the manor to the copyhold tenant. Where the lord or tenant are not absolutely entitled in fee simple, the transaction may be rendered valid by the consent of the Board of Agriculture and Fisheries (Copyhold Act, 1894, s. 14). The consideration may be a gross sum payable at once, a rent charge, a conveyance of land or of a right to mines or minerals, or a conveyance of a right to waste in lands belonging to the manor. An enfranchisement of land under the Copyhold Act will not, without the express consent in writing of the lord or tenant respectively, affect the estate or right of the lord or tenant in or to any mines, minerals, lime, clay, stone, gravel pits, or quarries, or the rights or

privileges of the lord in respect of any fairs, markets, rights of hunting, shooting, fishing, or fowling (Copyhold Act, 1894, s. 23).

Compulsory enfranchisement may be carried out either at the instance of the lord or the tenant. After notice requiring an enfranchisement, the compensation may be determined by agreement, or by the Board of Agriculture and Fisheries, or by a valuer or valuers agreed upon by the parties or appointed by the Board. The compensation will be an annual rent charge when the enfranchisement is made at the instance of the lord or where the sum payable amounts to more than one year's improved value of the land, unless the parties otherwise agree. The award will be made and confirmed by the Board of Agriculture and Fisheries when the compensation has been ascertained (Copyhold Act, 1894, s. 10) [A. J. S.]

Corchorus capsularis and **olitorius** are annual Asiatic plants belonging to the same nat. ord. as our well-known lime trees, namely Tiliaceæ. These plants are interesting because their fibre constitutes jute, which has now become a very important article of commerce. [A. N M'A.]

Cordial, in medicine, that which increases strength, raises the spirits, and gives life and cheerfulness to an animal when weak and depressed; anything that comforts, gladdens, and exhilarates. There are quite a large variety of stimulants, but probably the most popular one is alcohol in its various forms, whisky, ale, and stout; these are given to keep up the strength in wasting diseases; they should be used only to improve the appetite. If they fail in this they should be discontinued; for any apparent improvement in the strength will be obtained at the expense of the tissues. Strychnine or nux vomica is a valuable nerve stimulant, and the various preparations of ammonia have a similar action. [J. R. M'C.]

Cordwood is the name applied to stacks of firewood (of larger size than faggots), the term having arisen through the stacks being usually measured with a cord or line. It consists in the branchwood below timber size, under ancient custom included in the 'lop and top', which is thrown in to the buyer of the timber as a set-off for the cost of felling and logging the timber tree. The cord or stack of fuel varies greatly in size according to local custom in different counties, and even in different parts of any one county. Thus there are customary cords or stacks of $8 \times 4 \times 3 = 96$ cu. ft.; $12 \times 3 \times 3 = 108$ cu. ft.; $12 \times 3 \times 3\frac{1}{4} = 117$ cu. ft.; $12 \times 4 \times 3 = 144$ cu. ft.; $8 \times 4 \times 4 = 128$ cu. ft.; $6 \times 6 \times 6 = 216$ cu. ft. = 1 cu. fathom; and sometimes the cord of wood is reckoned as $2\frac{1}{2}$ tons or 125 cu. ft. The factor for converting stacked cordwood into solid contents varies from 0·35 to 0·5, according to circumstances. [J. N.]

Cordyceps entomorhiza (Insect Fungus).—This is a fungus which attacks and destroys the larvæ of the Garden Swift Moth (*Hepialus lupulinus*), &c. The spores germinate and pass their mycelia into the air pores of the larvæ, whose tissue they gradually invade until the whole becomes a mass of fungus. A large spore-bearing fructification is then passed out through the soil into the air, and the spores are released over the surface. In some districts Hepialid larvæ are very much attacked, and much good is done by this parasite. Infected soil may be removed to other parts where these subterranean insects are prevalent. [F. V. T.]

Cordyline, a genus of woody-stemmed trees of the lily family with strap-shaped leaves, and large branched panicles of small white, pink, or purple flowers. *C. australis*, a native of New Zealand, is the best known, and in Southern gardens it is quite a common feature, growing to a height of from 10 to 20 ft., often branching, and flowering almost every year. In the shelter of a conservatory it has grown to a height of 45 ft. There are several varieties of it, *C. Doucettii*, with variegated leaves; *C. lentiginosa*, with purple leaves; and *C. gracilis*, with linear red-striped leaves, being the commonest. They enjoy sunshine, and are not particular as to soil. [W. W.]

Coreopsis, a genus of annual or perennial herbs belonging to Compositæ. Many of the species have large handsome flowers coloured some shade of yellow or crimson. The annuals are easily raised from seeds sown in spring, whilst the perennials, which form clumps with fleshy roots, can be propagated by division. They are useful border plants, as they flower freely and continuously, and are decidedly decorative. The best of the annuals are *C. bicolor*, with yellow and brown flowers; *C. Drummondi*, bright-yellow; *C. grandiflora*, which grows a yard high and has large golden-yellow flowers; and *C. tinctoria*, of which there are orange and crimson flowered forms. The best of the perennial species are *C. lanceolata*, 3 ft. high, yellow, and *C. verticillata*, 2 ft. high, also yellow. [W. W.]

Coriander (*Coriandrum sativum*) is an annual umbelliferous plant flowering in June, and ripening its fruit in August. It is wild in the warm dry parts of southern Europe, but not in Britain. It is readily known by its radical leaves being pinnated, with broad, oblong, or roundish notched leaflets, while the stem leaves are divided into numerous linear segments; and by its globular fruits, which, when divided, are seen to consist of two hollow hemispheres, each hemisphere having on its back nine ribs, five of which are zigzag and four straight, as shown in the accompanying figure. The whole plant, when fresh, has a characteristic and very offensive odour, not unlike that of bugs; and the ripe fruit, called coriander seed, although aromatic, is by no means destitute of the same quality.

The plant is cultivated occasionally for the sake of the fruit, which is employed by confectioners, distillers, and rectifiers, and in medicine as an aromatic stimulant, for the purpose of correcting the odour and taste of nauseous drugs. It requires to be grown in good warm loamy land, and is usually sown broadcast in September, or in spring, its crop of seed being ripe in the succeeding August. If sown in the spring, it is apt, if the land is light, to die off at the time of flowering, without producing fruit.

The cultivation of this plant has been for many years carried on in the eastern counties, but more particularly in Essex, where it is sown along with caraway upon newly-broken-up pasture, or marsh land, which is especially adapted to its production. The coriander being an annual, is sown and harvested in the first year, but the caraway being a perennial, is harvested in the following and succeeding years.

The grass land designed for its cultivation should be ploughed up early in January, so as to become pulverized by frost; and about the middle of February the seed should be sown,

Coriander (*Coriandrum sativum*) and Fruit

or drilled, at the rate of ½ bus. per acre, and harrowed in; and if sown with caraway, the plants should be hoed out to about 10 in. apart, leaving the young caraway plants between at regular distances; if the plants are left too thickly, the amount of produce will be lessened, but the quality of the soil must in some measure be taken as a guide; on very rich soils, the plants may be left 12 in. or more apart. The cultivation must be well carried out by a first hoeing in about six or eight weeks from sowing, and a second hoeing will be afterwards necessary during the summer. When sufficiently ripe, it should be cut with hooks or sickles and placed lengthwise, in handfuls, on the stubble; and, when thoroughly dry, should be thrashed upon a cloth in the centre of the field, being conveyed to the thrashing place in sledges lined with canvas. It requires but little labour to thrash it out, but great care must be taken in moving it to the sledges, or much of the seed will be lost. The produce is from 10 to 25 cwt. per acre, but the quantity of seed is very uncertain, sometimes failing altogether; 15 cwt. may be assumed as an average crop on the best land. The straw is valueless, and is generally burned. It is rarely sown unless on rich maiden soils, and in connection with caraway.

[A. N. M'A.]

Corn, a general term for all the cereal grasses—wheat, barley, oats, rye, maize, rice. In the United States the term is applied almost exclusively to maize or Indian corn, while in Scotland it is popularly understood to refer to the oat crop.

Corn Aphis. See SIPHONOPHORA GRANARIA

Corn Bruiser. See BRUISER.

Corn Cockle (*Agrostemma Githago*) (Corn Campion, Rose Campion).—This is a poisonous light-land annual plant of the chickweed family, with its herbage covered by close hairs, which give it a hoary appearance. The stem is about 3 ft. high, and is swollen at every joint, whence proceeds a pair of narrow lanceolate leaves, which grow together at their base The flowers, which appear in June and July, are of a purple colour, stand on long stalks, and are surrounded by a hard, hairy, ribbed calyx, *longer than the purple corolla.* The fruit is a capsule splitting into five hard teeth, and containing a multitude of dark-brown, kidney-shaped, rough seeds filled with flour.

This plant is too common in cornfields in England. As it ripens its seeds along with the corn itself, the plants are necessarily reaped together, and when thrashed out, the seeds of the cockle, which winnowing will not separate, remain among the corn, from which they can only be removed by careful sifting. Whether ripe or unripe, the seeds of cockle are objectionable in wheat, not merely because they render the flour 'specky', but also because they make it unwholesome, since cockle seeds always contain the poisonous principle called saponine.

[J. L.] [A. N. M'A]

Corncrake. — The Corncrake or Landrail (*Crex pratensis*) is a summer visitor to this country, arriving about the end of April, and leaving again towards the end of September or beginning of October. It is somewhat locally distributed throughout Great Britain and Ireland, but where present it makes itself known by the continual repetition of its monotonous creaking note. It is heard far more often than it is seen; and when approached, runs with great rapidity, keeping carefully under cover. When it is compelled to take to flight, it is seen to be very weak on the wing; but in spite of this it finds its way every winter to the interior of Africa, where it remains during the cold months of the year. In summer it is found throughout central Europe, Russia, Norway, and Sweden, though scarce in the extreme north. Its usual resorts are meadows with long grass, fields of corn and clover, &c. Its food consists principally of worms, slugs, insects, and occasionally grass seeds, and the bird must be regarded as a good friend to the agriculturist. The nest is made on the ground, in good cover. So re-

luctant is the Corncrake to take to the wing, that if come upon suddenly it will often feign death, and allow itself to be taken up and examined, showing no sign of life.

[H. S. R. E.]

Corn-dressing Machine. See WINNOWER.

Corner.—It is said that this term was first used to indicate the position in a market when persons were under obligation to sell more of a commodity than they could obtain. They were then said to be 'cornered'. The situation implied that the buyers had first got control of supply, and the mere securing control of supply (whether it is accompanied by contracts to provide what is unobtainable except at a price fixed by those who have secured control of supply) is commonly referred to as creating a corner. The latter is now the most usual implication of the term. So interpreted, it means buying up such a proportion of a commodity as will endow the buyers with large powers of fixing price. Cornering has been facilitated, if not actually created, by the organization of produce markets, which render it possible for dealers to buy when the article is not before them, and may not yet exist, and by the development of financial organization which provides credit as means. One of the most highly developed of the produce markets is that in wheat. Several attempts have been made to corner wheat. The most famous of recent times was that of Leiter, which, after considerably affecting prices, ultimately failed. The cornering of the remnant of a seasonal supply is sometimes ventured. This may not involve portentously large financial operations. Such an undertaking is known technically as a 'squeeze'. Squeezes cannot be tried when supplies are continuous; and the more continuous supplies, and the greater the number of independent sources of supply, the less chance has a corner of succeeding. The world market in corn is now supplied from harvests which come at times spread throughout the year. With this market we may contrast the cotton market, the great bulk of the supply for which is forthcoming once a year. But even were supply perfectly continuous, if the holding of large stocks were customary, a corner might raise prices largely for a period. [S. J. C.]

Cornflower (*Centaurea Cyanus*).—This is a well-known Composite plant having a head of blue flowers. Chicory has also a head of blue flowers, but the florets of the head are strap-shaped, whereas in Cornflower all the florets are tubes. Cornflower is one of the gayest and most inoffensive of the annual and biennial weeds that infest corn crops. In gardens it is often cultivated, and there the colour sports from white to every shade of blue and purple.

[A. N. M'A.]

Corn Ground Beetle. See ZABRUS GIBBUS.

Corn Growing, Continuous. See FARMING, SYSTEMS OF.

Corn Laws.—One would expect the term 'corn laws' to refer to any legislation relating to corn; thus to include the laws forbidding the engrossing, forestalling, and regrating of corn and those intended to regulate its price. This, however, is hardly the case. By convention the term 'corn laws' has usually been confined in its application to laws bearing upon the importation and exportation of corn. Either class of trade might be restricted or encouraged, and theoretically there are therefore four classes of corn laws. The most common are those checking importation. The reason is that these laws have usually been aimed at (*a*) rendering a community self-supporting, and (*b*) benefiting the agriculturists and landed interest. The argument for the bounty on export was that, by encouraging farmers to aim at producing more than was wanted at home, the State ensured that there would be at least a sufficiency for home consumption in bad years. The only corn bounty Act of this country was the Bounty Act of 1689 (1 W. & M., s. 1, c. 12), which was extended to Scotland by 5 Anne, c. 8, and was slightly modified by 13 Geo. III, c. 43. Acts discouraging the importation of corn have been numerous. They began seemingly with the one enacted in the third year of the reign of Edward IV. This prohibited the importation of wheat, rye, and barley unless prices were above a certain defined limit. Regulations prohibitive of export have been frequent. They were intended to secure plenty at home in times of scarcity, or to cut off some supplies from the country's enemies. With the Act 22 Charles II, c. 13, the system of imposing import duties graduated according to prices was introduced. Wheat, rye, oats, malt, peas and beans, were all the subject of this piece of legislation. It remained in force unaltered until the less restrictive measure passed in the thirteenth year of the reign of George III. Consolidation of the corn laws, marking no appreciable change, however, followed in 1791. Severer restrictiveness was resorted to in 1815, when the high prices of the war period ceased. Various modifications followed. In 1846 it was decided to sweep away the corn laws altogether except for a shilling duty, which disappeared twenty years later. The repeal of the corn laws took effect in 1849. A shilling registration fee was imposed recently, but it is now removed. The repeal of the corn laws was largely brought about by the rise of a new important interest in the country. Prior to the 19th century, agriculture was regarded as a peculiarly national and valuable industry which must receive exceptional treatment. And the landed interest was the dominant interest. It was commonly held as the interest of the Government to legislate so as to bring about high rents. The potential financial resources of the Government were taken as varying with the amount of rent. Before 1840, however, manufactures had forced themselves into a position which challenged the exceptional claims of agriculture. The wealthy manufacturing and merchant class could no longer be easily subordinated to the landed interest. All concerned with manufactures were damaged by food being kept artificially high, as a high price of food meant high money wages, high money cost of production, and less demand for manufactured

products. The operative classes were also interested in getting cheap food. The repeal of the corn laws was eventually forced on the country by the national movement for which the Anti-corn-law League was responsible.

Perhaps the strongest argument for the State encouragement of agriculture is the advantage to a country of being self-supporting. If this country, however, had been forced to depend on its own food supplies it could not have maintained its present large population at nearly the same level of comfort. Cheap imported food resulted in a larger population and more wealth. Those who argue that present conditions, with food imports protected by the powerful fleet which they render possible, mean greater national strength than self-sufficiency associated with less wealth and a smaller population have no weak case.

It must be remembered that the corn laws were not continuously effective, owing to the level of prices and, in early days, to ignorance and evasion of the law. When effective, prohibitions on imports, duties on imports and bounties, would all tend to raise prices. Checks on imports, by keeping foreign corn out of the country and cutting off foreign competition, raised price. The bounty, in so far as it caused corn to be grown for export, as it would normally, necessitated higher cost of production (owing to intenser cultivation and the utilization of inferior land) and therefore higher prices. But actually in some years of failure of harvests it may have operated in keeping prices down. [S. J. C.]

Corn Marigold. See CHRYSANTHEMUM.

Corn Moth. See SITOTROGA GRANELLA.

Corn Rents.—The term 'corn rents' refers (1) to actual rents paid in corn, and also (2) to an abstract mode of regarding rent for purposes of explanation which was especially common in early economic writings.

1. Sometimes provisions were made that rents, or a part of them, should be paid in corn. Actually this meant that the rent payments should vary as the price of corn, or, otherwise expressed, the creation of a sliding scale connecting rents and the price of corn. In many cases, when the price of corn was varying considerably, arrangements of this kind were peculiarly equitable both to landlords and tenants. By an Act of 1576 (18 Eliz. c. 6) the colleges of Oxford and Cambridge, and Eton and Winchester, were empowered in the grant of fresh leases to reserve one-third of the rent as a corn rent.

2. 'Corn rent' means in economic theory rent reckoned in produce. For the purposes of this abstract representation the produce must be taken as one; hence the term 'corn rent'. Economics demonstrates that the return in corn (i.e. the produce) will increase as more capital is applied to a farm, but that after a time the increase will take place at a diminishing rate. It is shown that after a time the additional, or marginal, return multiplied by the investment of capital will be less than the total return. The difference (normal conditions being taken) is called corn rent. The value of corn rent at the average price of corn is the money rent in the abstract circumstances supposed. [S. J. C.]

Corn Returns Act.—By this Act, which was passed in 1882, weekly returns of the purchases of British corn are required to be made, under the direction of the Board of Agriculture, in manner provided by the said Act, from such towns in England and Wales, not less than 150 and not more than 200 in number, as may from time to time be fixed by the Privy Council. The average price of British corn is required to be from time to time ascertained from these returns and published by the Board of Agriculture in manner provided by the said Act. By Order in Council dated 26th November, 1900, weekly returns are made from the towns, 190 in number, enumerated in the Schedule to the Order. The Act does not apply to Scotland or Ireland. [D. B.]

Corns.—A bruise between the heel wall and the inflection called the bar of a horse's foot is known as a corn. The inner angle is the more frequent seat of this injury, partly because it is thinner than the outer wall, and owing to its being more immediately under the centre of gravity. More frequently found in the position described, it may nevertheless be discovered in both angles of the front as well as the hind feet. Feet of flat and weak conformation are predisposed to corn, but it is by no means rare in upright well-formed feet, when it may generally be traced to indifferent shoeing; excessive paring of the sole and bars and reduction of the heel; shoes too short and narrow, and long retained from motives of false economy, become embedded or 'grow in' as it is said, and so bring undue pressure upon the seat of corn. Corns are a serious objection in a horse, as there is a permanent disposition to them when once established. Recent corns show a discoloration of the horn close to the surface, and are cut out without difficulty. Those of old standing are deeper seated, and dependent ofttimes on a bruised condition of the heel of the pedal bone, which irritates the structures beneath. Neglected corns are liable to fester, and must then be laid bare by the knife and poulticed. Neglect of this results in the pus taking the least line of resistance and breaking through the coronet, a condition which may lead to quittor (which see). Lameness, more or less pronounced, is usually the first attractive symptom, save in the best-managed studs, where frequent examination of the feet takes place. An aloetic ball is recommended, while the pared-out heel is dressed with a weak carbolic lotion or friar's balsam, covered with a pledget of wool or muslin, and a bran-and-linseed poultice over all. When rest has restored the patient, he should be shod with leather as a protection. Some animals will work in a three-quarter shoe while the parts grow down and are permanently restored. [H. L.]

Corn Sawfly. See CEPHUS PYGMÆUS.

Cornus, a genus of shrubs or small trees comprising some thirty species, natives of temperate regions, two of them being British, viz. *C. sanguinea*, the Dogwood, young shoots of which are bright-red, the flowers white, and the fruit purple; and *C. suecica*, a small plant of little account. The Cornelian Cherry, *C. Mas*,

is a handsome tree which produces crowds of small yellow flowers in early spring; there is a form of it with variegated leaves. *C. capitata*, commonly known as *Benthamia fragifera*, is a tall tree with glaucous-green leaves and strawberry-like fruits. *C. Spathii* is a spreading hardy shrub with bright-yellow leaves, and is most decorative. [W. W.]

Corn Weevil. See CALANDRA GRANARIA.

Coronet is the name given to that part of the horse's foot where the skin blends with the hoof, or, as it is popularly termed, the hoof head The chief structure at this part is the 'coronary cushion', a delicate, highly vascular, and sensitive tissue, which secretes the horny material called the hoof in the same manner as the human nail is produced. The coronet in the horse, owing to its prominent position, is very liable to injury, and is commonly bruised or cut by the animal tramping on it when turning or twisting, especially when dragging heavy loads and shod with high heels. Injuries in this position frequently lead to serious results and prolonged lameness, and when the coronary cushion becomes inflamed it enlarges and projects as a thick ropelike circle around the hoof head, and often remains enlarged and prominent for the remainder of the animal's life.

In a like manner injuries in the neighbourhood may lead to the development of ringbones or sidebones, or, if suppuration supervenes, to the condition known as *quittor*, which is meant to indicate that the pus (or matter) is burrowing about in the substance of the coronary cushion, and bursts on to the surface at various points, leaving canals or fistulous openings through which the pus is discharged. The healthy coronet of a horse should be clean and devoid of swelling, any enlargement or tendency to ropiness being regarded with suspicion. [J. R. M'C.]

Corridale Sheep.—This is a comparatively new breed of sheep, which has been evolved in New Zealand since 1888, by crossing Lincoln rams with Merino ewes. By careful selection a breed of sheep has been evolved which combines in itself the excellent characteristics of both the Lincoln and the Merino. The Corridale sheep is possessed of a vigorous constitution and a capacity for growing a fleece of the finest combing wool. The rams command a ready market, and have been exported to Australia and South America.

Corrosive Sublimate.—Mercuric chloride, or perchloride of mercury, $HgCl_2$, is commonly known as 'corrosive sublimate', and is probably the most powerful and certain chemical disinfectant and antiseptic known. It is also a very powerful corrosive and irritant poison. It occurs as a heavy, white crystalline salt, which is readily soluble in water. It is also soluble in alcohol, ether, and glycerine. On account of its very poisonous nature it is generally recommended that for popular use it should be coloured, both when used in the solid form and in solution.

As a disinfectant mercuric chloride is much more powerful than either carbolic acid or chloride of lime. Its use is limited merely by its expense, and by the danger due to its very poisonous nature. Whereas it is said to take a solution of at least 1 in 100 of carbolic acid, and a solution of at least 1 in 2000 of chloride of lime, to destroy the spirillum of cholera or the bacillus of typhoid, a solution of about 1 in 10,000 of mercuric chloride will kill the same organisms. In the case of very resistant spores, such as those of anthrax, a much stronger solution is necessary. In this case it is said to be necessary to use a solution of 1 in 500.

On account of its great strength and certainty as a disinfectant, corrosive sublimate is relied on for a great many important purposes. Thus it is used for disinfecting hands, instruments, and the skin, &c., in surgical operations. It is used in midwifery, and in disinfecting the genital organs in cases of contagious abortion, and generally it is used for the disinfection of rooms, instruments, and contaminated articles in the case of dangerous infectious diseases, both of man and the lower animals. For these purposes, solutions of 1 in 500 to 1 in 2000, according to the nature of the substances to be treated, are generally used. A little hydrochloric acid is frequently added to the solutions, as it makes the action more certain and powerful. Solutions of corrosive sublimate should be made up in wooden, glass, or earthenware vessels, since mercuric chloride acts on and corrodes metals.

Another purpose for which corrosive sublimate is used is the preservation of museum specimens. It is also found in certain well-known preparations for preventing insect attacks on animals and destroying parasites. [J. H.]

Corylus, the botanical name of the common Hazel See HAZEL.

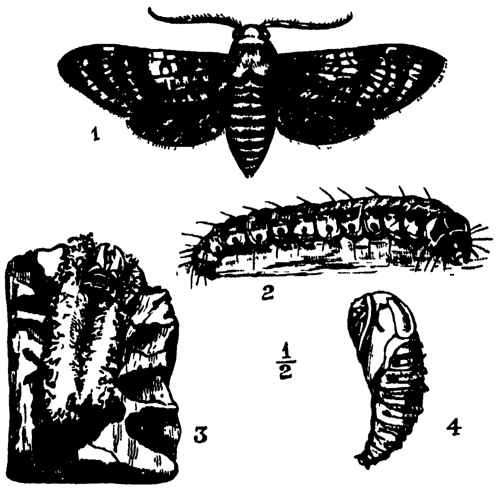
Corynetes violaceus (Death-watch Enemy), a small violet metallic beetle found crawling about in old houses, barns, stores, and stables. It lays its eggs in old woodwork attacked by the Death Watch and other wood-boring furniture and timber beetles. The larvæ feed on those destructive insects, and are thus of great benefit in checking the pests. [F. V. T.]

Cosmia trapezina (the Dun-bar Moth).—The caterpillars of this moth are carnivorous, and feed upon other larvæ. They do much good in devouring the green oak tortrix caterpillars. The moth is nearly 1½ in. in wing expanse, of an ochreous-grey hue, with darker central area to front wings. It appears in July and August. The larva is green, with a central and two lateral pairs of white lines and dark-green spots, and reaches 1 in. in length. It is found in May and June on oaks and birch, especially where other caterpillars abound. [F. V. T.]

Cossart or **Cosset.**—The term 'cossart' is indiscriminately applied to a lamb, calf, or foal which has been hand-reared in consequence of the death of its dam, or of its being a twin, and on that account receiving insufficient nourishment.

Cossus ligniperda (the Goat Moth).—This is a large moth of heavy and clumsy build, which reaches 3½ in. across the wings in the female, 2½ in. in the male; colour brown with grey marbling on the front wings, paler bands on

abdomen. It occurs all over Britain in June and July, and lays its eggs on ash, elm, oak, willow, &c. The caterpillars tunnel into the heart of the wood, and live there for three years, often not pupating until the fourth year. They reach up to 3½ in. in length when mature. When young they are dull-yellowish-red, but when mature the back is a rich mahogany-brown to brickdust-red, the sides dirty-yellow, two brown shield-like areas on the first segment, sucker feet dirty-yellow, the large horny brown head is furnished with very powerful jaws. The galleries they form are irregular. Before pupating, they come close to one of the openings in the bark and spin a cocoon mixed with wood chips, in which they change to large deep-brown pupæ with rings of spines. The pupal stage may be formed in autumn, or may not take place



Goat Moth (*Cossus ligniperda*)

1, Adult. 2, Larva. 3, Pupa in Cocoon in piece of Ashwood. 4, Pupa.

until the spring. Enormous damage is done to timber by these wood-borers, trees being killed in ten or twelve years if ash and willow, and somewhat longer in the case of elms.

Treatment consists of placing pieces of stick cyanide of potassium in the openings in the trunk and closing them up with clay. Neighbouring trees should be heavily smeared with a mixture of clay or cow dung and lime up to 3 ft. from ground in May to prevent egg-laying. [F. V. T.]

Cotentin Cattle, a breed of cattle found in the districts of Cotentin and Bessin in Normandy, noted for their large size, comparing very favourably in this respect with the Shorthorn. The prevailing colour is dark-red and white, with occasional black streaks on the body. The chief characteristics of this breed are: a short strong head, broad muzzle, large mouth, short crumpled horns, a large thick body set on short legs. The bones are large and coarse, the chest is somewhat narrow, and the quarters rather short, and the buttocks insufficiently developed; but the udder is large, and the teats of a good length. Cows of this breed are noted for the large yield and high quality of milk which they give. The milk is very rich in butter fat. Marchand, the French chemist, from numerous analyses gives an average percentage of 5·6 of butter fat. Butter made from this milk is possessed of a very fine flavour and aroma. Efforts are now being made to preserve the purity of this breed, and by careful selection to improve the confirmation and reduce the proportion of bone. The recent institution of a herd book among breeders of these cattle has gone far to achieve these ends.

Cotherstone Cheese, the one dainty cheese of the northern counties of England, though not by any means the only good one. Cotherstone ranks with Stilton, and indeed is a copy of it. It is not a 'double-cream' cheese, as was the Stilton of old, but just a 'whole-milk' cheese, as the Stilton of to-day generally, almost invariably, is Local methods of making account for whatever differences there may be between Cotherstone and Stilton, but the Yorkshire variety when ripe is blue-moulded, like the Stilton, but moister, and therefore mellower. It is not uncommonly preferred before the Stilton by epicures in cheese; yet, as no great quantity of it is made, it is not so generally known. [J. P. S.]

Cotoneaster, a large genus of evergreen or deciduous shrubs, most of which are quite hardy and of good constitution. Many of the species are Himalayan or Chinese. They flower and fruit freely, the bright-crimson colour of the berries being their great attraction. They are useful for clothing banks or walls, and some of them may be planted to serve as game cover, as they grow well in any soil, and birds greedily eat their fruits. They are easily propagated from seeds or by means of cuttings. The best known are *C. affinis*, which forms a small tree; *C angustifolia*, with narrow leaves and orange-coloured berries; *C. buxifolia*, a dense shrub with dark-red berries; *C. frigida*, one of the freest, and very handsome in winter when clothed with its red fruits; *C. horizontalis*, the stems of semi-prostrate habit, the leaves small and dark-green, the fruits oval and bright-red; *C. rotundifolia*, with long straight branches clothed with small round leaves and bright-scarlet berries; and *C. simmondsi*, a free grower with ovate leaves and orange berries. [W. W.]

Cotswold Sheep.—This hardy and handsome breed of long-woolled sheep takes its name from the Cotswold Hills—the 300,000 ac. or so of Oolite hills occupying the eastern and northern part of the county of Gloucester. The claim has been advanced, and with a fair show of probability behind it, that the Cotswold sheep are the original type from which a considerable proportion of the long-wool sheep of the country have sprung; soil, climate, management, and the skill of the breeders having combined to produce the great changes in form and appearance displayed in various districts. There is, indeed, strong presumptive evidence that the sheep of the Cotswold Hills are the direct descendants of the first imported specimens of the species, which made their appearance in Britain along with the other products of civilization charac-

COTSWOLD RAM—"LINCOLN ROYAL" (1155)
1ST PRIZE AT R A S E SHOW, 1907

COTSWOLD SHEARLING EWE
ONE OF 1ST PRIZE PEN AT R A S E SHOW, 1908

teristic of the Roman occupation. Certainly no other British breed possesses a distinct history of anything approaching the same antiquity. As far back as five or six hundred years ago historians and other writers are found making frequent reference to Cotswold sheep to the exclusion of any other breed, testifying to their predominant importance in those early times. There is ample historical evidence that the keeping of sheep and the working up of wool were carried on to a large extent throughout Saxon and Norman times in the Cotswold country around the town of Cirencester. But what is probably the earliest definite reference to the Cotswold breed occurs in the first part of the 14th century. In the Great Charter of Llanthony Abbey, about the year 1319, during the reign of Edward II, there is the record of a contract in which Geoffrey Merston, one of the richest wool merchants of Cirencester at that time, agreed to buy, at 11½ marks per sack, the 'Coteswolde wool' grown on the Llanthony Abbey lands at Barrington, in the very heart of the Cotswold country. In the reign of Edward III, 300,000 sacks of Cotswold wool was the annual quantity granted from the county of Gloucester for the king's household. In the 14th century the Florentines imported largely into this country, and in return for their goods 'they carried away wool and cloth which they were accustomed to travel to Cotteswolde to buy up'. In the 15th century it was enacted by 3 Henry VI, c. 2, 'that no sheep shall be exported without the king's licence', and there is no record of the king having been asked to grant a licence for any other than the Cotswold breed. About the middle of the 15th century we read of presents of Cotswold rams, ewes, and wool being sent by the English monarchs to the kings of Portugal and Castile, and the wool was exported to Italy for the manufacture of the cloth of gold. This would seem to indicate that the wool was finer and more lustrous than it is at the present time, and the practice of housing the sheep in early days—traces of which practice survive in such place names as Ampney Sheephouse, Sheep Cot, and Cot Hill—would, no doubt, tend to improve the quality and texture of the wool. At home the fame of the breed is reflected in the contemporary writings. Markham, who wrote on agricultural matters in the reign of Queen Elizabeth, described Cotswold sheep as a long-woolled and large-boned breed. In Camden's Britannia we read of—

> 'Cotswold hillocks famed for weighty sheep with golden fleeces clothed'.

Drayton a little later wrote:

> 'Cotswold, that great king of shepherds,
> T' whom Sarum's plain gives place, though famous for her flocks,
> Yet hardly does she tythe our Cotswold's wealthy locks'.

And, writing enthusiastically of the shepherd's life on these hills, incidentally he gives an interesting description of the Cotswold sheep of his day (1563–1631):

> 'No browne nor fulleyed black the face or legs doth streak,
> . . . . but Cotswold wisely fills
> Hers with the whitest kind; whose browes so wooly be
> As men in her faire sheepe no emptiness should see;
> The staple deepe and thick, thro' to the very graine;
> Most strongly keepeth out the violentest rain;
> And of the fleecie face, the flanks doth nothing lack,
> But everywhere is stored, the belly as the back,
> As white as winter's snowe'.

Sufficient has been said on the score of the antiquity of the breed, and it need, perhaps, hardly be added that the Cotswold sheep of the present day is a very different style of animal from his remote and unimproved predecessor. A judicious introduction of Leicester blood by the chief breeders of over a hundred years ago, coupled with a careful process of improvement and selection, had a beneficial effect on what was formerly a large, flat-sided, and somewhat leggy animal; but while the quality was enhanced, the size of the carcass was not sacrificed, nor the vigour of the constitution impaired. About the same period 'the great enclosures' began, and the improvement of winter feeding by the introduction of the turnip was another element in the development of the breed both in form and in early maturity, the result being that by degrees it was found that, instead of keeping the wether sheep two years, it was possible to have them both fat enough and heavy enough at one year old.

The excellence of the breed thus improved attracted pretty general attention to the annual sales of the Cotswold ram breeders, which were established toward the end of the 18th century, and the sheep were distributed all over the British Isles, while a brisk foreign demand also sprung up. Amongst the counties in which pure-bred flocks were established (outside the hills of Gloucestershire and Oxfordshire) were Wilts, Hereford, Worcester, Glamorgan, Norfolk, Kent, and Somerset, and it was found that the sheep adapted themselves readily to almost every difference of climate and food. But as an old breed of great hardiness and size, the Cotswold was most largely sought after for crossing purposes, and it is probable that most of our English breeds have at one time or another secured some improvement in regard of size and character by the introduction of Cotswold blood. Indeed, the Cotswold sire is the parent of one of the most popular, as it is certainly the largest, of our Down breeds, for the Oxfordshire Downs were introduced from a cross of Cotswold rams with Hampshire Down ewes, and it was not till 1857 that the name of Oxfordshire Down was formally adopted by the new breed in substitution for the original one of Down-Cotswold.

Although, as has been said, the Cotswold sheep can adapt himself with equanimity to a more generous diet than he usually gets at home, he is capable of enduring, and indeed thriving under, great hardships, and he will put on flesh when standing up to his knees in mud through an inclement winter, under conditions in which many of his now more favoured rivals would need the utmost care

to keep life in them. This hardiness of constitution is, of course, of the utmost value to the hill farmers of Gloucestershire, whether they keep purebred Cotswolds (which only a comparatively few now do), or, as is more commonly the case, crossbred flocks in which the Cotswold blood is largely represented. The Cotswold is, in truth, valuable for crossing with any breed in which greater size, longer wool, fatter backs, and earlier maturity are required; and though they have not been used for crossing inferior breeds in other countries to the same extent as the Lincoln and the Leicester, there is no doubt that the Cotswold breed is superior to these in hardiness and ability to thrive on poor soil. Cotswold rams, when properly selected, are capable of serving Scotch ewes on the bleakest mountains as well as either Border-Leicesters or Wensleydales, and have been used with much success for that purpose The first cross with either Cheviot or Blackfaced Scotch ewes is an excellent one, and the wool of the latter cross has been pronounced by a prominent Bradford wool merchant and manufacturer to be the equal if not the superior of any crossbred wool he had ever bought. The wool of the Cotswold lacks the special fineness, firmness, and lustre which gives the Lincoln such a command of the Argentine market, but the breed is growing in favour among flockmasters in the United States and in Canada, whither a considerable number of rams are sent year by year. Recently an experimental consignment has been purchased by an Australian importer.

The following pen-portrait of an ideal Cotswold of the present day was drawn in the essay prefixed to the first volume of the Cotswold Sheep Society's Flock Book. The head should be wide between the eyes, and the eye itself full, dark, and prominent, but mild and kindly, and in no way coarse about the brow. The face should be proportionately wide to the space between the eyes, but not too flat, and should run of much the same width to the nostrils, which must be well expanded and somewhat broader than the face, with the skin on the nose of a dark colour. The cheek is full and, as is the face, well covered with white hair, a just perceptible blue tinge on the cheek and round the eye being rather 'fancied'. The ear long and not heavy, of medium thickness, and covered with the same short soft hair; it should be well carried up, while black spots on the point of the ear are not considered objectionable. The top of the head should not be coarse nor bald, but covered with *wool*, not hair, and the Cotswold is to be distinguished by a fine tuft of wool on the forehead. The head should be sufficiently long to save it from being called short and thick, but it should not have a long, lean appearance. Grey faces still crop up occasionally in all the best flocks. The neck should be big and muscular, and should be gently curved, to enable the sheep to carry the head well up, thereby giving the animal a grand appearance. The neck should be slightly smaller at the ears than where it comes from the shoulders. The shoulders should lay well back, and the point of the shoulder should be well covered with flesh, as also the chines. The ribs should be deep, well sprung from the back; the hips and loin wide, and well covered with flesh. The rump should be carried out on a level with the back, giving the animal a square-looking frame; the leg of mutton well let down to the hock, and thick on the outside. The legs, both front and hind, should be straight, moderate in length, and set well outside the body. The pastern joints, both front and hind, should be short. The whole body should have a firm solid touch (not loose and flabby), and be well covered with a thick-set, long, and lustrous fleece.

The mutton yielded by Cotswold sheep is succulent and well flavoured, especially when young, and although the modern taste in favour of leaner meat compels the acceptance of a lower price per lb. for Cotswold than for Down mutton, this is to a sensible extent compensated for by the consumption of fewer roots and far less artificial food in proportion to the meat produced. Indeed, when the quality of the breed is carefully maintained, and moderate size and firm flesh is bred from, the quality need not fear comparison with that of many other breeds. In point of early maturity, Cotswolds occupy a foremost place among the flocks of the country. With ordinary feeding, they can be brought to market at from nine to twelve months old, weighing from 90 to 112 lb., while it is no unusual thing for the best flocks to turn out 120 or 130 lb sheep at that age. Although it is not the practice of Cotswold flockmasters to breed from ram lambs, this is from no want on the part of the lambs of size and early maturity, for since the lamb classes have been introduced into the prize schedule of the Royal Agricultural Society the lambs of the Cotswold breed have frequently been among the best in the show. In 1892 a pen of three Cotswold lambs scaled no less than 6 cwt. 1 qr. 23 lb. It may safely be asserted that no sheep makes a more liberal return in mutton for the food expended on him than the Cotswold. This was established in feeding experiments carried out as far back as 1856 by the late Sir John Lawes, and recorded in the Journal of the Royal Agricultural Society. The sheep experimented upon were Hampshire Downs, Sussex Downs, Cotswolds, Leicesters, and Crossbreds, and the results showed that 'the Cotswolds consumed the least food to produce a given amount of increase'. Later trials have confirmed this conclusion. No doubt in their early history they were at least as much, or more, valued for their wool as for their mutton produce. The staple of the wool is long and mellow, and for weight and substance it has few rivals. The average weight of the fleece throughout a well-managed first-rate flock would be from 9 to 11 lb. of washed wool. That the wool-producing qualities of the Cotswold sheep are well maintained is shown by the result of the clip of the celebrated Aldsworth flock (Messrs. W. T. Garne & Son's) in 1905, when 1100 fleeces produced 417 tods of washed wool, or an average of 10½ lb. per fleece. An old breeder of repute once

summed up the excellences of the Cotswolds as follows, and although some allowance must be made for the judgment of a partial critic, there is not much fault to be found with the conclusions which he draws, especially when it is remembered that it is the poor arable land of their native hills that he had in his mind. He says: 'There is no breed in the world so perfect as the Cotswolds, taking all their points. They are Leicesters of a large type, only very superior in loin and rump. They are remarkable for their constitution, and, being bred on poor land, improve rapidly in most other countries. As a cross they improve all other breeds. I have no doubt, having been crossed with Downs, they constitute the Shropshire Down breed. They will live hard, cut a vast quantity of wool, fat readily, and come to enormous weights of the most delicious mutton; are less liable to disease, and are the best mothers to their lambs of any breed known.'

As regards the management of Cotswold flocks, the lambing pen is generally placed in a turnip field, and constructed of thatched hurdles divided into convenient pens well littered with straw, which is considered more healthy both for ewes and lambs than a permanent lambing pen at the homestead. After lambing (which begins about the 1st of January), when the young lambs are well on their legs, the ewes run out daily on the turnips, or have a field of kale, and return to the shelter of the pen at night. If the land is very wet they are shifted to a dry pasture or seed field, and provided with some rough temporary shelter. They are kept on the roots and hay from January to May, and in due course a water meadow, Italian ryegrass, or an early field of seeds, a mixture of sainfoin, clover, and ryegrass, provides food for both lambs and ewes, some roots being thrown to them daily. During summer they are run thinly on seeds until the lambs are weaned in July, when the lambs are put on vetches, lattermath sanfoin, or clover, the ewes being given a bare bite on pasture or seeds in order to dry up their milk. In September, rape or early turnips provide food for the lambs, the wethers being pushed with cake for the butcher, and the ewe lambs put on roots again and kept in thriving condition in order to take their place in the breeding flock the succeeding year. The ewes are put to the tup about this time. The show sheep, having been done well from the time they were put on the vetches when weaned, are now put in the house and specially fed, about half their wool being cut off. The house feeding until the end of December consists of linseed cake, beans, and cut roots.

As Cotswolds are liable to lose some of their native hardiness when transplanted to other and richer soil, constitution naturally is a leading feature with the home breeder who wishes to find a market for his rams, and the moderate feeding of the flock is important in this connection. Rich meadow or arable land and sandy or peaty soil are all much less fit for Cotswolds than poor soil on limestone or chalk formation, and they will thrive better when thinly stocked on poor land than when thickly stocked on good land. The quieter they are allowed to lie, and the less they are dogged or driven, the better, as their disposition is essentially quiet, and from their weight they suffer more from hard driving than lighter breeds. The ewes will live on almost nothing in summer if they have water and quiet. They are less liable to foot rot than Down breeds, and when well managed are subject to very few diseases. They never do better than when folded on roots, where they will endure a great deal of cold, wet, and mud with surprising ease, and fatten quicker than any other sheep under such conditions. Good mothers, they bring up twins well, keeping their flesh better, and recovering it more quickly after weaning than most other breeds.

The Cotswold breed has invariably and exclusively been in the hands of tenant farmers, and has therefore lacked the benefit to be derived from the support of wealthy patrons who would create a market or set a fashion; but even so, Cotswold men have always been distinguished by spirited enterprise. In the national showyards they have cut a creditable figure, for although they were not awarded a separate class by the Royal Agricultural Society until 1862, every year previous to that they carried off all the honours in the only class open to them, that for 'Longwools not Leicesters'. Of late years the number of exhibiting breeders has been very limited, and unless an improvement takes place in this direction it will not be surprising if the classification offered to the breed is still further reduced.

Although Cotswold breeders had for many years done a considerable export trade, and although their breed of sheep yielded to no other in the country in antiquity and authenticity of history, they were among the latest to establish a Breed Society and to start a Flock Book—a step which was necessary for placing their flocks in their proper position in the livestock annals of the kingdom. One explanation of their delay is probably to be found in the fact that the chief breeders were able to supply, from their own private and carefully kept flock books, pedigrees which satisfied the requirements of foreign purchasers. But in view of the increasing stringency of the regulations imposed by foreign countries with regard to the importation of pedigree stock, it was seen that action was essential, and accordingly in September, 1891, the establishment of the Cotswold Sheep Society and the publication of a Flock Book was decided on. By this time the number of purebred flocks had become considerably reduced—the demand for lean mutton and the greatly lessened value of wool having had a combined influence in this direction that was found irresistible. Since then there has been a still further diminution, and the area in which purebred Cotswold flocks are kept has become still more restricted. The first volume of the Cotswold Flock Book contained the record of 45 flocks—31 in Gloucestershire, 6 in Oxfordshire, 1 in Wiltshire, 2 in Herefordshire, 1 in Worcestershire, 2 in Berkshire, and 2 in Norfolk—with a total of over 12,500 ewes. The present number of registered flocks is only 15

—10 in Gloucestershire, 2 in Oxfordshire, and 3 in Norfolk—with a total of under 4000 ewes. How much the breed has fallen in popular favour may be gathered from the fact that between fifty and sixty years ago it was estimated that in Gloucestershire alone 5000 rams were sold and let in a season, at a total price of little less than £15,000. Some ten years later the number of rams sold annually was put at about 4000, and the foreign demand was still vigorous. Since then numbers have gradually declined, though it is satisfactory that there are still a sufficient number of well-managed flocks surviving to guarantee the preservation of the purity and vigour of this ancient and valuable breed.

In their palmy days, when their wealthy fleeces were filling the pockets of their owners, the annual Cotswold ram sales were an important event of the agricultural year. These sales, which were started as early as 1785, were at first conducted by private contract, breeders announcing the dates on which their rams would be ready for inspection, and their customers then assembling and dealing for the sheep which met their fancy. Later on, the practice of holding auctions at the homesteads was resorted to, and the series of ram sales on the Cotswold Hills formed an extensive round of hospitable and social reunions, at which a considerable amount of business was done in addition to the sale of the rams on offer, from a dozen to a score of such gatherings taking place during the months of July and August. These fixtures have gradually been abandoned. [W. S. H.]

Cottages.—No subject presents much greater difficulty in country districts to-day than the housing of agricultural labour. Fortunately its requirements are generally met by the existing cottages and occasional trifling improvements; but when the time comes that patching no longer avails, and rebuilding becomes necessary, or an increasing population has to be provided for, it will be found that the cost of building and the burdensome restrictions of local authorities make it practically impossible to do so and receive a reasonable return for the outlay. Happily local authorities are moderating their views, and realizing that it is not necessary to inflict on rural districts the stringent regulations governing building in our towns; but beyond this there is little hope for reducing the cost of building. Undoubtedly in the long run the cheapest thing to use is local labour and local material. Both having a reputation to maintain, they are likely to be the best procurable for the money.

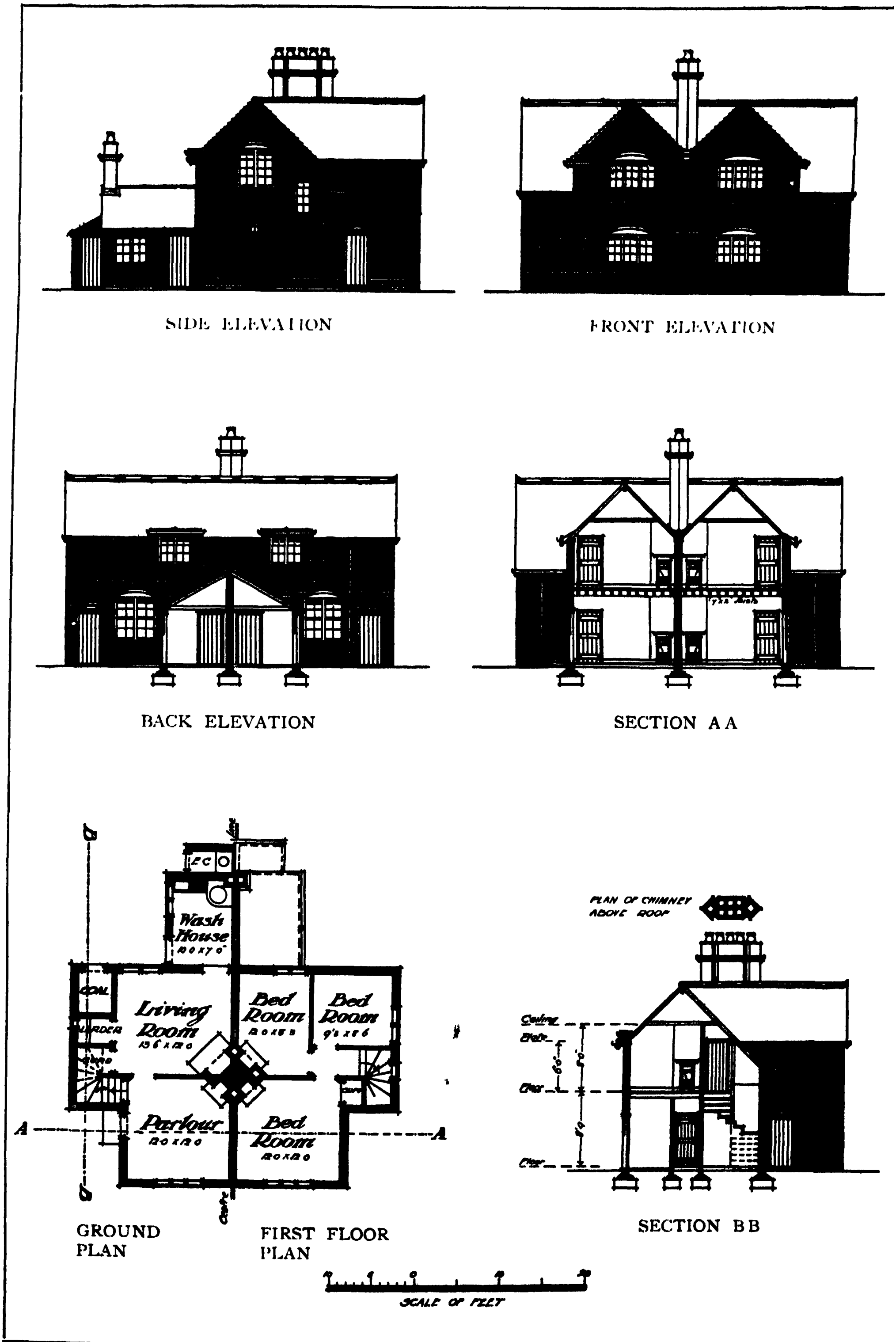
Before discussing any details of arrangement it would be well to look first at the essentials of site and water supply. The first of these does not generally engage much attention, any convenient spot being thought good enough; but the duties of our labourers' women folk confine them so closely to their houses that an effort should be made to place them in such a position that the outlook may be bright and cheerful, as well as healthy. A view—a sunny slope—both have this tendency; but should the house have to be on the north side of a road, let it be built at the back of the site, so that the garden may be on the sunny and sheltered side of the house, and clear of the shadow thrown by it. An eye might also be given to protection from prevailing winds and rain. To further ensure peaceful enjoyment to the tenants, where cottages are built in pairs or rows (by far the cheapest plan), let no consideration of cost ever permit of common washhouses, rainwater butts, or such conveniences.

After the selection of site, the next point is the water supply. The soft water from the roofs will naturally be collected in waterbutts, or, better still, in a soft-water tank below ground; but this supply cannot be relied upon solely, and failing other sources a well should be sunk and a good supply assured before any building takes place. The old open well with bucket gear is a most insanitary and unsatisfactory thing, and every modern well should be closed in and fitted with a pump, and care exercised that the well when sunk shall be free from all contamination.

The question of drainage is one of the most troublesome, for, as a rule, the labouring classes treat the matter with contemptuous indifference, and for this reason dead wells and water closets should never be employed where avoidable. Unless, therefore, a sewer is available, earth closets should be used. This leaves only the sink waste to deal with, and, unless the luxury of a bath is provided, it should be easily disposed of in a percolating well. These wells are built of well-bricks, with every fourth course in mortar and all the rest laid dry, so that the liquids can soak away. They must be built at a safe distance from the water supply. The earth closets should be of the simplest type, and nothing can be better than the special galvanized iron pails made for the purpose and fitted with wood seat Below the seat and in front of the pail should be a hinged flap, so as to admit of the pail being easily removed for emptying These earth closets are generally built attached to the cottage, but the old plan of building them entirely detached in some convenient corner of the garden is undoubtedly the most sanitary and best.

Before starting to plan a cottage it must be settled whether it is to contain a parlour as well as a living room. There can be no question that the majority of tenants have a strong attachment for a parlour, in which they enshrine their household gods, and practically never use; but, on the other hand, with its omission a very much larger, and therefore more comfortable and healthy, living-room can be provided without any addition to the cost. This is clearly shown in the plans accompanying this article. Plates A and B both have three bedrooms, washhouse, &c., but Plate A is shown with small living-room and parlour, whilst Plate B has a large living-room only. The difference in cost for the pair is £40 in favour of the latter scheme. Whichever plan is adopted, there should be a comfortable seat by the fire, free from opening doors and draughts, and a similar seat by the window to work by. A cupboard for china and table stores should be provided, and the range fitted with open-fire arrangement.

The washhouse or scullery should also have



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A. Elevations and Plan of Pair of Cottages with Living Room, Parlour, and Three Bedrooms

a fireplace for cooking, as well as a furnace pan. This latter should be of 20 gal. capacity at least. A glazed stoneware sink and draining board should be provided, and the floor finished with a smooth surface in cement, which will enable it to be kept clean with a minimum of labour. The larder, besides the necessary shelves, should have a removable frame to the window, fitted with flyproof gauze.

The staircase should not be less in width than 2 ft. 9 in., with sufficient head-room, and direct enough to enable furniture to be carried up and down, whilst for the safety of the users the treads should be not less than 9 in. wide, nor the risers more than 8 in. high. A handrail should always be provided.

The bedroom floor should have not less than three rooms, for it is impossible to expect families to be brought up in decency with a less provision. Neither should any room be approached through one of the others; where this is the case it is the outcome of nothing but incapable and careless planning, and no such plan should be adopted. The accompanying plans show how simply it may be avoided without any waste of space in the bedrooms. It is not necessary that each room should have a fireplace, but one room at least should have this provision, in case of any illness, when it might be necessary. With so many badly conceived plans about, no apology is needed for mentioning that each bedroom should be planned so as to leave a convenient spot for the bed and the necessary bedroom furniture. A small cupboard for linen should be provided where possible.

The height of rooms is generally governed by local by-laws, but where they do not exist, 8 ft. clear from floor to under side of joists may be adopted as a satisfactory height. In bedrooms, if half the area of the ceiling be of this height it will be quite sufficient, and, except with flat-pitched roofs, the wall - plate from which the rafters spring may be brought as low as 6 ft., or even less, when the windows can be put in the gable end, or a dormer formed to ensure the head of the window being near enough to the ceiling to provide proper ventilation.

In a work of this nature it would be impossible to discuss the various constructive methods and materials that may be employed in building, and it will be enough, therefore, to advise that local custom and materials should be closely followed, not only for the economic reasons already urged, or for the æsthetic reason that strange material and design appear incongruous in a rural district, but conformity to local usage will ensure the work being better done, as it will be understood by the local craftsmen. Thus brick and tile, stone and slate, each should be used in its own district in the manner most common to that district.

But whatever material is employed, let the foundations and damp-course be good. Cement is so cheap nowadays that it is no extravagance to have the foundations of cement concrete, and good foundations will save much future expense in settlements and repairs. The damp-course may be of two courses of slate laid lapping in cement.

If the walls are of brick, it should be remembered that, except in very sheltered situations, and with a very good brick, a 9-in. wall cannot be guaranteed weatherproof. To make it so the wall can be built hollow, with special brick or iron ties, or it can be coated outside with stucco or rough-cast This last-named plan has been much used of late years and is deservedly popular, as it not only renders the house warm and weatherproof, but is as cheap as, if not cheaper than, the plain brickwork; for a rougher and cheaper brick may be used, there is no pointing, nor finished arches to door and window openings, and these economies can thus be set against the extra cost of stucco.

For the roof of a cottage, thatch or plain tiles make the warmest and most picturesque covering. The former, however, on account of its relatively short life and high cost, can only be used under circumstances where cost is of subsidiary importance; the latter, with the head of the tiles bedded in mortar, makes a sound and lasting job, but should not be used on roofs where the slope is less than 45° Slates and pantiles are cheaper, and can be used on a roof of a much flatter pitch with safety, but they are not possessed of the qualities claimed for thatch and tiles. Good wide projecting eaves to a building greatly improve its appearance and protect the walls from the weather; but whether these are employed or not, guttering and down-pipes to collect and carry away the roof water are necessities.

For the windows of a cottage the double-hung sash has many advantages, but it is not so cheap nor so picturesque as mullioned casements, whilst these latter have the further advantage of much greater strength, the frequent props afforded to the head by the mullions making the frame so strong as to be almost independent of a relieving arch to carry the superincumbent load. Much of the trouble with dropped arches and settlements is hereby avoided. If the back of jamb next brickwork has a large groove worked in it, say 2 in. long and ⅝ in. deep, and this is grouted up in cement every three courses as the frame is built in, not only will great strength be added to the work, but it will be quite weatherproof without having the frame in reveal, and thus the frame may be set back 1½ in. only from the face of brickwork, with great advantage to the appearance of the building and added width to the window board. It also makes it possible to dispense with a stone sill, as the oak sill may be made of sufficient width to project 2 in in front of brickwork, and worked with a check groove underneath to prevent water from running down the face of the wall, with perfectly satisfactory results. To get good results from the use of casement windows, it should be carefully observed that the space between mullions is not more than 18 in. Whatever type of window is employed, it should be remembered that the main object of a window is to supply sufficient light and air for the healthful enjoyment of the room. Let windows therefore be large enough, and keep the head close enough to the ceiling to provide efficient ventilation.

For cottage work, ledged doors sheeted with 1-in. V-grooved boarding are quite good enough, and much cheaper and better than the 'shoddy' panel doors so often employed. They may be fitted with either Norfolk latches or iron rim latches at much the same cost. A picture-rail about 18 in. below the ceiling costs very little, and will save the plastering from being knocked about, whilst the airy appearance of the room is much improved by whitening the frieze above same in with the ceiling.

If possible, a lean-to shed or open-fronted shelter should be provided, for storing kindling for immediate use, and such things as garden tools, washtubs, &c., for which there is little accommodation in the cottage.

To turn to a description of the designs accompanying this article. Plate A shows a cottage with parlour, living-room, and washhouse on the ground floor. No porch or lobby is shown to the entrance door to parlour, which, however, could easily be contrived by carrying down sloping roof over staircase; but it hardly seems necessary, for this door will never be used except by a chance caller, it being certain that the family will invariably use the back entrance, and take off dirty boots or wet garments in the washhouse. A larder and good-sized cupboard under the stairs are provided, approached from the living-room, whilst a concrete path outside the back door gives easy access to coal house and earth closet The washhouse is fitted with furnace pan, sink, and draining board. The first-floor plan provides three well-shaped bedrooms and a linen cupboard, the space occupied by the staircase being economized as much as possible, that no space may be lost to the rooms Built as shown of brick, with plain tile roof, the cost for the pair would be £395.

Plate B, whilst having similar accommodation on the bedroom floor, is quite different on the ground floor. Instead of a washhouse, with living room and parlour, it has only the former and one large living-room 18 ft. long. To give greater comfort and warmth to this room an entrance lobby is provided, whilst the lobby also gives an independent approach to the staircase. The earth closet, it is proposed, should be built entirely detached from the house, as already advocated. Built as shown of brick and rough-cast, with plain tiled roof, the cost of the pair would be £355. A brick plinth is shown to this design. It is to prevent the necessity of bringing the rough-cast right down to the ground, when it would be badly splashed by mud during every rainstorm. The plinth is formed by merely building it of two half-brick thicknesses with 1½ in. space between, and the rough-cast is then weathered down on to same.

Though these plans are illustrated as built of brick and tile, they are equally adaptable to any materials by adapting the thickness of the walls to the materials used. For fuller specification, reference may be made to that given for houses in art. on Buildings. [H. M. C.]

Cottiers.—The term 'cottier', as connected with agriculture, was derived from Ireland. Originally it was applied to cottagers who were sub-tenants under small farmers and rented a cottage and one or two acres of ground, but it has come to be applied to the small farmers themselves. Its meaning is somewhat indefinite, but it may be taken to imply small farmers of the peasant class whose rents are determined by competition. The system worked disastrously because alternative occupations were inadequate, and the tenants, bidding against each other, offered more than they could pay. The misery of the cottiers and the stagnation, or even decay, of agriculture was the result. The consequent evils led to the new departure of the Irish Land Acts of 1870 and 1881.

[S. J. C.]

Cotton.—The cotton fibre may be defined as the floss found around the seeds of certain species of Gossypium, a genus of perennial bushes or small trees of the nat ord. Malvaceæ, the mallows. The species are widely dispersed on both sides of the Equator and in both hemispheres. Moreover, by cultivation the area of distribution has been greatly extended beyond the wild habitat In other words, the attainment of annual forms has allowed of production during the summer months in regions where the severity of winter would certainly have killed perennial stocks. Hence on the north, cotton growing extends to 45°, and on the south to 35° of latitude, or about 20° both north and south beyond what might be called the natural region of the wild species. Cotton is thus essentially a product of tropical agriculture, but one which through comparatively modern adaptations has been carried into all the warm temperate tracts of the globe.

The Cotton Plant.—The greatest possible ambiguity prevails in the determination of the species, varieties, and races of the cotton plant that are engaging the attention of growers. This very largely proceeds from the unfortunate circumstance that the botanical names given by the early authors were intended to denote cultivated, not wild species. unfortunate because there are some seventeen wild species which, down to the early decades of the 19th century, had received no names; unfortunate also because hardly had the names that were given to the cultivated forms been published than the plants in question so changed that in most cases they could no longer be recognized. Had the early botanists selected the wild species as the basis of their systematic studies, a fixity would thereby have been attained (at present entirely absent) from which it might have been possible to work out with some certainty not only the histories of the cultivated forms, but to establish the guiding lines for future improvement. This is therefore not a botanical quibble, but a difficulty of vital importance to which at least the growers cannot be indifferent. It may be quite true that the merchants know when they have got the particular staple they require, and are indifferent as to whether it may be called *Gossypium herbaceum*, *G. hirsutum*, *G. mexicanum*, or *G. peruvianum*, or simply Short Staple, Long Staple, Georgian, Egyptian, &c. The trade as a rule is in fact much more concerned with the country of production than with the botanical origin of the plant. But if the required fibre

cannot be supplied in sufficient abundance or at a remunerative price, then it is customary to blame every person concerned, to call for new areas of supply, and to lavish money and advice, it may be in the least practical directions. The question of the preservation and progression of the staple of each country is thus essentially a problem of agriculture in which the nature of stock grown can no longer be neglected than can selection to climatic and soil requirements.

The following statement of the cottons of the world may therefore be useful as affording the botanical names of the chief wild and cultivated forms, their more striking characteristics, and the countries of their production:—

Section I.—Species with a fuzz (or velvet coating on the seed) but no separable floss, and with the bracteoles that embrace the flower quite free from each other and sometimes even clawed (or possessed of stalks).—All the eight species that fall into this position are *wild* plants that in the majority of cases possess no fibre that could justify cultivation. They may be accepted as represented by *G. Sturtii* of Australia; *G. Klotzschianum* and *G. Darwinii* of the Galapagos; *G. tomentosum* of Hawaii; and *G. Stocksii* of India and Arabia.

Section II.—Fuzzy-seeded floss-bearing species with united bracteoles.—This assemblage possesses two *wild* and some ten or twelve *cultivated* forms. They are met with from the shores of the Mediterranean through Africa, Egypt, Arabia, Asia Minor, Kurdistan, Persia, India, China, Japan, and Malaya. The wild (or perhaps rather feral) species are *G. arboreum*—a plant more closely associated with Africa than with India—and *G. obtusifolium*, the wild cotton of Gujarat The cultivated forms are. (1) *G. arboreum*, the tree cotton or *nurma* of India and the red-flowered cotton of Africa; (2) var. *neglecta*, Bengal cotton; (3) var. *assamica*, Garo hill cotton; (4) *G. Nanking*, Chinese and Japanese cottons; (5) var. *himalayana*, the temperate or hill cottons of India: (6) var. *Nadam*, Coconada, and also much of the Deccan and Burma cottons; (7) var. *Bani*, the Berar and Nagpur cottons (Oomras, Hinganghats, &c); (8) var. *Roji*, the Gujarat tree cotton; (9) var. *soudanensis*, Soudan country cotton; (10) *G obtusifolium* var. *Wightiana*, sometimes called the Gujarat long staple; (11) var. *africana*, the indigenous cottons of Eastern and Western Africa; and lastly (12) *G. herbaceum*, the cotton of the Levant, Upper Egypt, Abyssinia, Arabia, Asia Minor, Persia, and Afghanistan (but not of India nor of China).

Section III.—Fuzzy-seeded and floss-bearing species with the bracteoles practically free.—There are five *wild* and five *cultivated* forms. American plants with one species also African; but none Asiatic—except as recent experimental cultivation. The wild species are *G. mustelinum*, found in Brazil and Colombia; *G. punctatum*, a species with two well-marked varieties (perhaps species), var. *jamaica*, the American and West Indian form, and var. *nigeria*, the African; *G. Palmerii*, Mexico; *G. Scholtii*, Yucatan; and *G. lanceolatum*, Mexico. From these to a large extent have been derived the following cultivated species: (13) *G. hirsutum*, the green-seeded cotton of some of the early authors, New Orleans, Georgian, short staple American, saw-ginned Dharwar, and *tonje manga* (Zambesi); (14) var. *religiosa*, the Khaki cotton, Roman cotton, &c.; (15) *G. microcarpum*, Red Peruvian, a form fairly largely grown in Egypt and Africa; (16) *G. peruvianum*, South American cotton, Peruvian (*imbabura*) or Andes cotton, Egyptian (*Ashmouni*, *Mit Afifi*, *Zafiri*, *Abassi*, &c.) and perhaps also the Pernambuco cotton; (17) *G. mexicanum*, Mexican cotton and the bulk of the Upper American grades (*e g* Cluster, Semi-cluster, Early Small Boll, Peterkin, Prolific Medium Boll, Long Staple, Big Boll, Storm-proof, &c.). All these are hybrid races, so that the commercial terms applied to them have often a loose signification For example, Long Staple might mean a cotton of the *G. mexicanum* series with a strong strain of *G. barbadense*, or it might be applied to lower grades of Sea Island, or even to some Egyptian cottons (see next section).

Section IV.—Naked-seeded (that is to say possessed of a readily separable floss, but of no under coat of velvet or fuzz), bracteoles free or nearly so, and floral glands conspicuous.—There are one *wild* and four *cultivated* species, the former distinctly referable to this position and the latter mainly so. The wild species is Polynesian, and the others so closely associated with South America as to give the impression they may have originated there. The wild form is *G. taitense*, a plant found very plentifully in Tahiti, but also in the Mascarene and Malayan Islands. The cultivated forms are: (18) *G purpurascens*, Bourbon, Porto Rico, &c., cottons—a perennial plant at the present day often found in a feral state. Met with from Hainan to New Caledonia, and westward to the Andaman Islands, South India, Madagascar, East Africa, Upper Egypt, and the West Indies; (19) *G. vitifolium*, most of the long-staple Egyptian, Antilles, Piura, Surinam, Guadeloupe, Barbados, &c., (20) *G. barbadense* var. *maritima*, Sea Island, long staple United States, and some of the finer Egyptians; lastly (21) *G. brasiliense*, Brazilian, Guiana, Costa Rica—chain and kidney cotton.

Section V.—Naked-seeded cotton, with bracteoles quite free and floral glands absent, but the attachment of the bracteoles by means of a rigid constriction and thickening of the base that often simulates both external and internal glands.—There is only one species referable to this position—*G. Kirkii*, a *wild* plant met with in East Africa.

Such, then, in brief, are the cultivated cottons of the world, associated with three out of the five sections of wild species. While the characteristics of the wild cottons manifest the customary degree of constancy, the commercial races possess no single feature that could be depended on by itself as even fairly diagnostic—a circumstance that strongly supports belief in the value of hybridization as an agent in racial production. Here and there manifestations exist in fact that can alone be explained by the supposition that there may have been other ancestral forms than those at present known. For example, it is difficult to believe

that the chief diagnostic peculiarities of *G. Nanking*, *G. herbaceum*, and *G. brasiliense* could have been developed from any of the known wild species. It seems preferable to think that there may have existed other forms than the seventeen wild species with which we are at present acquainted.

Cultivation seems in other words to have brought about certain very striking departures from the standards of the wild species. Thus a somewhat singular feature, and one of much practical value, is that all the wild species have a red-coloured fuzz or red-coloured fuzz and floss. Then again, from being perennials the bulk of the more highly valued stocks have become annuals. Distinctive features based on the degree of fuzziness or nakedness, on the condition of the bracteoles, or on the nature of the glands, have been greatly obscured, or under recessive manifestations have come and gone in a perfectly bewildering fashion. Selection and adaptation to profitable production have altered

A Sprig of Cotton (*Gossypium barbadense*) showing Flowers and Bolls

the number of the cells in the fruit, disturbed the number and relative size of the seeds present, as also the length, colour, and physical properties of the staple. White has, for example, become the prevailing colour of the most prized forms, and woolliness given place to silkiness. The wild or feral cottons have a short, thick, harsh, imperfectly and irregularly twisted fibre, while the highly cultivated forms have a long, thin, and uniformly much-twisted silky staple. Both in the Asiatic and North American habitats a large, coarse, fuzzy seed with firmly adhering woolly floss is met with. From Polynesia and South America apparently came the much-prized influence of a naked seed, due to the possession of a readily separable floss. Lastly, from South America we were first made familiar with the somewhat novel condition of naked seeds conglomerated into a chain and kidney mass. This was described in connection with the cotton of Brazil in the middle of the 16th century. But so far as at present known, no truly wild plant possesses that property, though it is so constantly associated with other characteristics in leaf, flower, and fruit as to have conveyed the impression that these features collectively denote a definite species—an ancestral condition that has proved of much value in the production of some of the prized forms of modern cultivation. To be able to take full advantage of the results obtained by other investigators, it accordingly becomes imperative to recognize the species, varieties, and races of the cotton plant on a botanical basis such as that indicated above.

CULTIVATION.—The production of perennial cottons is confined to tropical countries, and even there they are grown more as hedges around gardens or as protecting lines through fields—mixed cultivation, one row of cotton to eight or ten of cereals. Formerly a more extensive production prevailed and systems of cultivation were common, long since abandoned and forgotten. The species most frequently recorded as having been thus raised are *G. arboreum*, *G. Nanking*, *G. purpurascens*, *G. vitifolium*, and *G. brasiliense*. The cultivation generally pursued might be described as having been one of ratooning. Seeds were planted in rows 6 ft. apart, and on the seedlings becoming 2 to 3 ft. high they were cut back to within 3 in. of the ground. This caused a branching to take place, so that bushes rather than trees were formed. On the first crop being collected the plants were again cut back nearly level with the ground, and this was repeated every two or three years until the age of twenty years had been reached, when they were uprooted. In some localities the plants were not allowed to grow for more than half that time, and of others a third crop was spoken of as the maximum desirable, since, with longer cultivation, degeneration of the staple was understood to ensue. The modern production of perennial cottons might be characterized as dictated through the absence of soils suited for the annual forms, or as a consequence of the prevalence of strong winds during the fruiting season. It is commonly held that the perennial forms of *G. Nanking* (the species most frequently resorted to for this purpose) may be grown on poor or stony and high soils, where other cultivation is almost impossible.

In India.—To illustrate the cultivation and results with annual cottons it may suffice to give particulars of the two greatest producing countries, India and the United States of America. The former stretches from 8° to 32° N. latitude, and the latter from 30° to 37° N. latitude. Hence the chief cotton area of India is distinctly tropical, while that of the States is at most only semi-tropical. Moreover, the greater diversity of India introduces a wide range of possibilities. Hence it may not inaccurately be said that the herbaceous or annual cottons of India are mainly dependent on the season of the rains, and in the United States on the duration of the heat. In the greater part of the Indian cotton area the monsoon sets in about June, and the seed is therefore sown in June–July; but if the rain is exceptionally heavy, or should it fail temporarily, the seedlings may be killed and a second or even a third sowing be rendered necessary. Cotton thrives best on deep 'black-cotton' loam, with a fair admixture of sand, and with a rainfall of 20 to 40 in., provided it falls at timely intervals during the growing stage and not during the season of picking the floss. In other words, dry weather is required for ripening and harvesting. In Gujarat (the region of the finest Indian cottons) preparatory tillage commences in April–May, and manure is rarely given oftener than once in three years. Cotton is grown on the same field every second year, and irrigation is rarely resorted to. The seeds are drill sown 20 to 25 in. apart, and when the plants are 4 in. high the fields are intercultivated and weeded. Weaklings are pulled up by the roots, and the plants left are 18 in. to 2 ft. apart each way. Finally, a second ploughing between the rows is given in September–October, and picking the floss commences in January and is complete by the end of April. This is the most general harvest period, but it is at once restricted and earlier crops or seasons necessitated where liability to frost occurs. An important modification of this system prevails where there is a second monsoon (north-east), in October–December. Were the sowings to be made in June (with the south-west monsoon), the crop would ripen and be destroyed during the second period of rainfall. In Dharwar, for example, sowing takes place in the latter part of August and is extended to September, so that a plant of a more temperate nature is found best suited for such conditions, and for these reasons very possibly the greater success has been attained in the acclimatization of American cotton on the uplands of the Karnatak than in most other parts of India.

Between these two extremes there is a wide range. In consequence the harvest extends from November to August according to the plant grown, the altitude of the locality, and the season of the year selected for cotton cultivation. Indeed it is not unusual for two crops of cotton to be taken a year in the same district, an early crop being sown during the monsoon in June and harvested in the cold weather (December–February), and the late crop sown at the close of the rainy season and harvested during the hot weather (April–May) This condition prevails over a great part of Bengal and the United Provinces. Two crops are also taken in Madras.

The Indian cultivator has an extensive series of plants to select from that may be used in rotation, but with land specially suited for cotton it is a common practice to allow it to lie fallow during the alternate years. The millets—*juar* (*Sorghum vulgare*) and *bajra* (*Pennisetum typhoideum*)—are the chief plants used in rotation with cotton, the former on heavy, the latter on light soils; but other crops are also met with, such as sesame, gram (*Cicer arietinum*), *dal* (*Cajanus indicus*), coriander, &c. In many parts of the country mixed cultivation prevails, that is to say rows of the alternate crops are sown through the cotton fields, especially when protection from prevalent winds is found necessary.

From the considerations mentioned it may be inferred that it is often exceedingly difficult to furnish statistical information that could be accepted as applicable to the whole of India. As shown, two crops a year may be obtained in some localities, while in others cotton is often largely grown as a mixed crop. It would, however, seem probable that a yield of 100 lb. clean cotton per acre (300 lb. seed-cotton) would be over rather than under the mark—a figure that may be regarded as raised to 150 lb. with two-crop cultivation. For pure cultivation the cost might possibly range from Rs15 to Rs30 an acre (£1 to £2).

The area and production returned in 1904-5 came to 14,918,000 ac. and 3,826,000 bales; in 1905-6, 21,072,000 ac. and 3,426,000 bales; and in 1906-7, 22,344,000 ac. and 4,908,000 bales (of 400 lb.). In the last-mentioned year half the production was exported as raw cotton and one quarter as manufactures (mostly yarns), thus leaving one quarter as required to meet local demands. If the valuation shown for the exports be accepted as applicable to the portion retained in the country, the total value of the crop would be £20,000,000 irrespective of the seed.

In the United States.—Turning now to the United States, in contrast with India it may be said truly that, while the youngest, this is certainly the most important cotton-producing country in the world. In proof of this statement, witness the fact that the cotton exports of the States equal in value all their other agricultural exports put together. And that stupendous achievement represents the industry of the farmers in the so-called 'cotton belt' or southern section, which comprises ten States. In 1904-5 it was ascertained that these produced 13½ out of the 17¾ million bales (of 499 lb.) which constituted the world's supply. The median point of production would be within a radius of 75 miles drawn from Jackson, Mississippi. It may also be said that the growth of this great industry is exemplified by the returns of production. In 1888-9 there were 19,362,073 ac under the crop, and in 1904-5 that area had expanded to 31,730,371 ac. But the extension of the cotton region westward across the Mississippi has been in recent years its most significant feature, together with a progression from primitive to civilized agriculture. That there is still much room for improvement is abundantly shown by the fact that while the average yield of lint for all the States is only 190 lb. (roughly double that of India), as much as 500 to 800 lb. have been obtained with careful selection of stock, generous supply of manure, and a fair amount of labour bestowed on the crop. It has accordingly been urged that all that is needed to make the cotton belt keep pace with the demands of increasing consumption is to abandon the system of land-rotting and take to that of land-building. It would probably be not far from correct to put the average fair cultivation as costing \$24·46, the price paid for the floss \$36·50, thus leaving a net profit of \$12·04 plus the price obtained for the seed.

As to the climate of the cotton belt, since it lies above 32° N. latitude it might be described as a warm-temperate region, with an equable temperature and a long growing season, a moderate and well-distributed rainfall and a fair amount of sunshine. But its chief dangers are the great liability to pests, more especially the boll weevil, and the approach of autumn frosts. If, therefore, the growing season be shortened, or excessive rainfall occur, or cloudy weather obscure the sun, then a poor crop may be expected. There is no particular soil that could be spoken of as characteristic of the whole of the cotton belt—hence to some extent the diversity of produce. On rich soils the plants grow large and yield higher crops, and are accordingly planted farther apart than on poor soils. To this same circumstance also is due very largely the diversity of stocks, one plant having been found better suited to a certain class of soil than another. But sooner or later sterility must ensue, and the old system become imperative, namely, the abandonment and opening out of new lands, if methodical and systematic agriculture be not pursued.

Throughout the greater part of the belt the one-crop system may be said to prevail, but with the more advanced farmers a rotation has come into use something like the following: *first year*, corn during summer, cow pea during the fall; *second year*, cotton during summer, oats or wheat during the fall; and *third year*, cow pea during the summer, and rye and clover during the fall. Cotton is a far less exhausting crop than corn or wheat, and yet it cannot be grown continuously without serious injury to the soil. On this account high-class manuring is steadily becoming the rule rather than the exception. It is recognized, in fact, that to shorten the growing season the surest and most certain method is to furnish specific fertilizers, and further, that on good land the benefits of this course are even more pronounced than on low-grade soils. Moreover, it is freely recognized that early maturity is very much more a question of stock than of methods of cultivation and quality of manure.

As to seasons, nearly every State or definite area has its own particular season for sowing and reaping, so that no general rule can be laid down. Sowing commences, for example, in South Texas on the 1st, in East Texas and Louisiana on the 15th, in South Mississippi and South Carolina on the 20th March; in Middle Texas and Arkansas on the 1st, and in North Carolina and Georgia on the 20th April. The period of sowing is greatly restricted by liability to late frosts, since these are injurious to young, as the autumn frosts are to the mature plants. It may, however, be noted that the average United States crop has its first three months of growth in part of April, May, June, and July, while the average Indian crop is only germinated in June and has its first three months in July, August, and September. The advancing climatic conditions of the one, and the declining temperature of the other, have been claimed as the explanation of the superiority of the one staple as compared with that of the other. As a matter of fact, however, the bursting of the tropical monsoon throws back the temperature to such an extent that the comparison becomes questionable. Still, however, the two conditions are undoubtedly very dissimilar, and perhaps the dictates of a shortening period of growth may very materially disturb the plant economy.

In the States, deep ploughing is highly recommended as a preparatory measure, and repeated weeding and surface tillage after the plants have germinated. But in America the rows of cotton plants are farther apart than in India, about 4 ft. being the usual condition on good soils, and 3 ft. on low-grade, the plants being 20 to 25 in. apart on the rows. Less than 3 ft. is discouraged, since interculture is impossible,

and the collection of the crop thereby rendered difficult.

Thus it may be accepted as abundantly established that cotton cultivation is the most important phase in the agriculture of the United States. This view may be regarded as confirmed by an inspection of the cotton-manufacturing interests of the world. In 1904–5 there were 6014 cotton mills in the world. Of these 2077 were in Great Britain, 1201 in the United States, 500 in Italy, 420 in France, 390 in Germany, 304 in Russia and Poland, 257 in Spain, 203 in India, 64 in Japan, and 22 in Canada, the balance in less important centres. The United States and India have thus (together with Egypt, the West Indies, Africa, Brazil, &c.) to meet the demands of 4600 mills other than their own (1404). Hence, apart altogether from the arguments that might be urged in favour of manufacture within the countries of production, it must not be forgotten that the stupendous production of the United States and of India has been the direct consequence of the establishment of cotton manufacture as the central feature of European (modern) enterprise in the textile industries. The cotton interests of the world as now established, therefore, seem likely to demand a continuance of the present arrangement, namely, a production in the United States and in India far in excess of their home consumption. Cotton to these countries is therefore essentially an agricultural product, and as such it seems likely to remain for many years to come. While that is so, the efforts of the British Cotton Growing Association and of other such organizations, to extend cotton production in all suitable countries, have met with considerable success, and seem likely in the future to attain even greater results. As compared with the United States and with India, however, it need only be added that the cotton area of Egypt was last year only 1,500,000 ac., or one-fifteenth of that of India.

Cotton-seed and Oil.—Any account of cotton would be incomplete were the importance and value of the seed as a source of oil, cattle food, and fertilizer to be entirely omitted from consideration. Indeed it is one of the most startling of the many surprises in the cotton industry of both India and the United States that the seeds should have been for so very long entirely neglected. On the seed-cotton being collected, it is conveyed by the farmer to the ginning factory in order to have the seed separated from the lint. Formerly the seed was regarded as of so little value that it was thrown into the nearest river and thus washed away. In fact, laws had to be passed in the States against the great piles of rotting seeds that became a public nuisance. At the present moment it is estimated that $100,000,000 are paid for the crop, a sum that equals about one-fifth the value of the lint. Besides yielding oil and cakes, the seed is made into meal, while its value as a fertilizer has almost obscured its utility as an article of cattle food. Speaking of India, it may be said that in five years, from being utterly insignificant, the exports of cotton-seed have sprung into the second place in quantity and the fourth in value of all the oil-seeds exported. But even these very large exports do not represent more than from 10 to 20 per cent of the amount available, and a large proportion of what remains in the country is utterly wasted.

There are various grades of oil produced from the seed, the finest being largely used in cookery and for admixture with olive oil. The cake, left after expression of the oil, is steadily gaining popular favour in Europe and America as an article of cattle food. So important a branch in cotton cultivation has the sales of the seed become, that it has been suggested the plant might almost be grown for its oil-seed alone. See art. Cotton Cakes. [G. W.]

Cotton Cakes.—Cotton cake is the residue left after pressing out the oil from the seed of the cotton plant (see art. Cotton). The Sea Island, or long-staple, cotton seed, after undergoing the process of cleaning called 'ginning', can be obtained nearly free from attaching cotton fibre, and it is this seed which is in most favour for the manufacture of common or undecorticated cotton cake. It is a larger and bolder seed than that of other varieties. That which comes from Egypt has the highest reputation and commands the highest price, and seed of this kind, and cake made from it, are generally known in commerce as 'Egyptian'. The Upland, or short-staple, cotton seed, on the other hand, is a smaller seed, and has a close packing of short fibres which are not removed in the ordinary process of 'ginning'. In the United States it has been usual to remove the outer shell of the seed, with the attaching fibre, and to press the kernel alone, the cake so obtained being known as 'decorticated' cotton cake. Up to recent times only the long-staple cotton seed was used for crushing whole and making the common or 'undecorticated' cotton cake, the presence of the woolly fibrous matter being regarded as constituting a danger to stock if fed to them, owing to the tendency of the fibre to 'mat' together, and to collect the food in a lump in its passage through the intestines, and thereby causing stoppage. Of late, opinion on this point has undergone some modification, and, consequent on an increased demand and the larger output of cotton seed from India principally, there has been an extensive use of the upland or short-staple cotton seed for pressing it whole and making it into cake without previous 'decortication' (husk removal). This class of cake is now known generally under the name 'Bombay cotton cake', and there is an increasing export and trade in it. Decorticated cotton cake continues to be made in America, and it also comes over to this country largely in the form of meal. The 'hulls' with the attaching fibre used to be burnt as fuel, but both in India and in America they are now at times given to cattle. There have been many attempts to get some satisfactory process for removing the fibre, or 'lint' as it is termed, from the seed, and these have included the treatment of the seed with acids and subsequent neutralization with alkali. But this treatment is open to objection, as it is difficult not to injure the seed, and it has been practically abandoned, and reliance has been placed on improved machinery for 'delinting'

the seed. More recently, improved methods of machinery have resulted in the manufacture of decorticated cotton cake in this country as well as in America. From Brazil, Peru, and other parts of South America come also certain quantities of the undecorticated cake, but these have to be regarded with some suspicion; the seed is often pressed in coarse horse-hair bags, and there is also a liability for the cake to contain castor-oil bean, through carelessness in the storing of the seed or in the manufacture.

In the course of time, considerable changes in the general composition of cotton cakes—whether undecorticated or decorticated—have been experienced, and anyone now reading accounts of decorticated cotton cake, written, say, twenty years, or even ten years ago, or referring to analyses given at those times, would have to considerably modify his views to fit the present date. Nevertheless, cotton cake has always held a high place in the opinion of the feeder of stock, and very rightly so, and it will continue to do this, for, next possibly to linseed, there is no seed of more value to the farmer, or the introduction of which, in one of its purchasable forms, has proved of greater benefit to the farm, whether considered from the feeding or the manurial point of view.

COMMON OR UNDECORTICATED COTTON CAKE.—This, as at present in use in this country, comes forward, as stated, in two principal forms, these being called, for convenience, 'Egyptian cotton cake' and 'Bombay cotton cake'. In each case the whole seed is crushed in mills, the meal steamed in 'kettles', and the oil expressed by hydraulic presses. The uncrushed Egyptian seed contains about 22 per cent of oil against about 17½ per cent in the Bombay seed; the latter has, as one would expect, the higher proportion of husk, this amounting to about 49 per cent of the whole seed as against 40 per cent in the Egyptian seed. The dense packing of cotton fibre on the Bombay seed has already been referred to, and its presence in the manufactured cake is very apparent.

The composition of Egyptian cotton cake has not materially altered since it was first introduced; improvements in machinery for pressing out the oil have perhaps lowered slightly the percentage of oil, but this remains, as an average, at about 5 per cent, though occasionally there will be found cakes that give 5½ per cent; this latter figure is, however, seldom exceeded. Bombay cake gives a rather lower percentage of oil, and it is also lower in albuminoids, as will be seen on reference to the analyses on next column.

Another point to notice as between Egyptian and Bombay cake is that while the former seldom contains more than 0·25 per cent of sand, the latter usually has over 1 per cent, and this quantity, where the seed has not been properly cleaned, may go up to 2 or even 3 per cent. This should not occur, of course, but is due, no doubt, to the short fibres holding firmly particles of earth and sand. In regard to the husk, and whether it and the attaching fibre are harmful to stock, or the reverse, there has been considerable controversy, some alleging that it must be risky to feed, others asserting that, if given with proper precautions, there is no risk attending its use, and, indeed, that there are cases where it may even do good, as, for instance, when cattle are newly put on pasture. All are agreed, however, that the Bombay cake is not a material to be given to other than maturing animals. It has, further, been stated that the husk of Bombay cake, though larger in amount than in Egyptian cake, is more easily digested than is that of the latter, and it would appear that there may be some grounds for supporting this view. No one, however, would be disposed to contend, either from a scientific or practical point of view, that husk and wool were, in themselves, 'food', though the risk attaching to the use of cake containing them in quantity may have been exaggerated. The truth probably lies in this, that if Bombay or other cake containing much husk and wool be fed without taking proper care, or be given too freely, or to stock for which it is unsuited, it may do, and has undoubtedly done, harm; but that if used with care and discretion, it may be profitably employed. In any case, however, good Egyptian cake is the safer food, and, by reason of its richer composition, should be the better food were prices equal. It is on the somewhat lower price of Bombay cake that the question turns mainly with the ordinary farmer. The difference between the two classes of cake varies considerably with the market and the demand, but, as a rule, does not go beyond 10*s.* to 15*s.* per ton. It should also be pointed out that Bombay cake is by no means universally the same article; there is good Bombay cake and bad, and care should be taken to avoid that which is made from seed excessively woolly or improperly cleaned. When Bombay cake first came on the market, there was a considerable amount of adulteration of Egyptian cake by mixing with the seed a certain quantity of Bombay seed. This, however, did not go on long, for J. A. Voelcker (see Analyst, 1903, 28, 261) pointed out the microscopical and other differences between the two kinds of seed, and how the presence of each seed could be detected. A vigorous series of prosecutions under the Fertilizers and Feeding-stuffs Act followed on this, and the adulteration soon ceased entirely. Undecorticated cotton cake, as a matter of fact, is

AVERAGE COMPOSITION OF UNDECORTICATED COTTON CAKE AND DECORTICATED COTTON CAKE

	Undecorticated Cotton Cake		Decorticated Cotton Cake.
	'Egyptian.'	'Bombay'	
Moisture	12·3	11·6	8·7
Oil . .	5·1	4·6	9·9
[1] Albuminous compounds	22·9	19·4	39·1
Digestible carbo-hydrates, &c.	33·7	38·0	28·0
Woody fibre .	20·7	20·1	7·2
Mineral matter	5·3	6 3	7·1
	100·0	100·0	100·0
[1] Containing nitrogen	3 6	3·1	6·2

very seldom adulterated. Occasionally, castor-oil bean is found in it, coming in accidentally, but the only addition found at all frequently is borax, it being a custom with some makers to add a small quantity of borax in the manufacture in order to preserve the bright appearance of freshly-made cake, and to prevent the cake turning mouldy, as it will not keep well long unless carefully stored. Such additions of 'chemicals' are, however, objectionable, and if cake be made from good sound seed there is no call for their use, one which tends to give a fictitious appearance to the cake.

Undecorticated cotton cake is a most valuable food, and one very extensively used on the farm. Of the total nitrogenous bodies in it, 94 per cent consist of true albuminoids. Its albuminoid ratio is 1 : 3. Of its different constituents, 74 per cent of the nitrogenous bodies are digestible, 90 per cent of the fat, and 51 per cent of the soluble carbohydrates. The presence of the husk must certainly not be looked upon as that of merely extraneous or useless matter, for the husk undoubtedly possesses an astringency which is very serviceable when cattle are put out on fresh pasture, the astringency checking the tendency to 'scour', and cotton cake is very largely used for this purpose. Undecorticated cotton cake is also an excellent food for milk cows, and it has the effect of producing a white and firm butter. Incidentally it may be mentioned that if cotton cake be fed at all freely to dairy cows, it is found that the butter will give the reactions for cotton-seed oil. For fattening stock a very favourite practice with many feeders is to give linseed cake and cotton cake half and half. Cotton cake would seem to be more useful in the earlier stages of feeding, or when given on grass land, than for finishing beasts for the market. It is not a suitable food for young stock or for lambs. It forms perhaps the most general constituent of compound feeding cakes.

From the manurial point of view, undecorticated cotton cake stands high in the list of purchased feedingstuffs. In 1000 parts it contains 35·2 parts of nitrogen, 25·8 parts of phosphoric acid, and 16·1 parts of potash, its compensation value for each ton consumed being—

Last year.	Second year.	Third year.	Fourth year
33*s*. 9*d*.	16*s*. 10*d*.	8*s*. 5*d*.	4*s*. 2*d*.

Occasionally, especially when damaged and unfit for feeding, it is used directly as manure on the land, after being ground into meal.

Decorticated Cotton Cake.—This is the most concentrated of all the purchased foods used on the farm, and it is also that to which the highest manurial value attaches. Its composition is set out in the analysis already given (see p. 60). Its market price in relation to its composition is more moderate than is the case with any other food, and were it not for certain disadvantages connected with its manufacture and supply, it would undoubtedly be the most economical of all farm foods, especially as it possesses the advantage that what is not utilized by the animal goes to form the richest manure produced. No farmyard manure is so valuable as that for which decorticated cotton cake has been liberally fed. This cake is the most highly nitrogenous of all the foods used, whether purchased or home-grown. Its albuminoid ratio is 1 : 1·3, and of its total nitrogenous bodies 96 per cent consist of true albuminoids. Of the nitrogenous matters, 87 per cent are digestible, 95 per cent of the fat, and 76 per cent of the soluble carbohydrates. Like undecorticated cotton cake, it should not be given to young animals, but for maturing animals or milking cows there is no better food. It is not suitable for pigs. Experiments conducted on more than one occasion at the Woburn Experimental Farm have shown that for fattening cattle it is considerably more economical than undecorticated cotton cake. Being so highly nitrogenous, it is best used with a mixture of some starchy food, such as maize. Excellent results have been obtained at the Woburn Experimental Farm by using decorticated cotton cake, linseed cake, and maize meal, in equal parts, for fattening bullocks.

In respect of manurial value, 1000 parts of the cake contain 62 parts of nitrogen, 32·5 parts of phosphoric acid, and 15·8 parts of potash, and the compensation value for each ton consumed is—

Last year.	Second year.	Third year.	Fourth year.
56*s*. 5*d*.	28*s*. 2*d*.	14*s*. 1*d*.	7*s*.

It thus stands at the head of the Table of compensation values.

When decorticated cotton cake first came into use it was carefully made, being soft, and rich in oil. It was then not uncommon to find it contain 16 and 18 per cent of oil. The consequence was that it came rapidly into request. But, so soon as its value was found out and acknowledged, the care given to its manufacture was dropped, and its quality gradually deteriorated, owing, in great measure, to the desire to press more oil out of it The makers in America, finding that it would sell freely whatever its condition, took no special trouble, as they knew they could readily sell all that they had to offer Consequently the cake sent over to this country came to be more and more hard-pressed, and to be lower in oil, and at the present time it is seldom that a much higher amount of oil than 10 per cent is found. There were also difficulties with the hard lumps which at times occurred in it, through the meal collecting together in balls in the steaming kettles and being subsequently pressed together; these lumps were not unfrequently the cause of trouble with stock feeding on the cake. Next, the decortication was not as well done as before, and the percentage of husk left in was increased. To remedy in some way these defects, the plan was introduced of grinding up the cakes into meal, and this was, for a time, made up into cake again in this country. It had the advantage of giving a softer cake, but it was only the lower-quality cakes that were so ground, and the reputation of the cake sank still lower. With the introduction of the meal came in also one of those disabilities to which the purchase of meals is always subject—the liability to adulteration. Adulteration in this case took

mainly the form of first decorticating the seed and then grinding up the husks and mixing them again with the meal! It became thus a matter of great difficulty to say what amount of husk belonged to the original decortication and what amount was subsequently added. The joint result of these various devices, practised, it should be said, in America and not in this country, has been to lower still further the quality of decorticated cotton cake, and to cause it to be much poorer in oil and higher in fibre than it used to be. This is much to be regretted, for, as pointed out, despite all these drawbacks, decorticated cotton cake is still one of the most valuable, and probably the most economical food on the farm. Occasionally, as when damaged, the meal is used direct on the land as manure. [J. A. V.]

Cotton Grass, or Narrow-leaved Cotton Grass (*Eriophorum angustifolium*), is not a grass

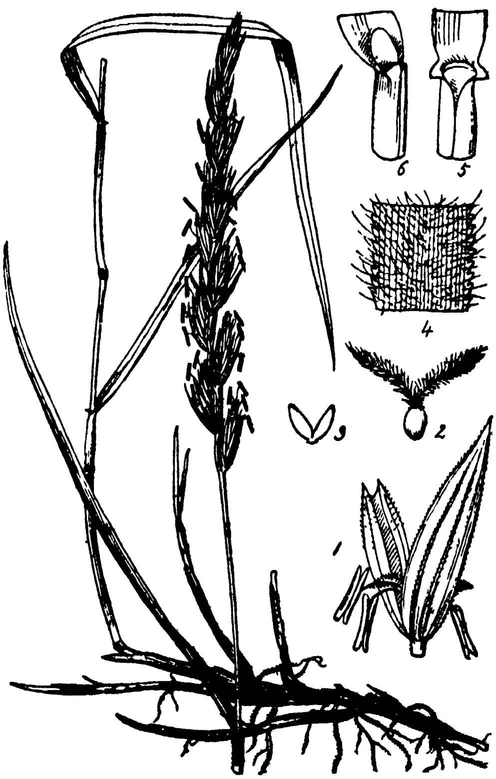
Cotton Grass (*Eriophorum angustifolium*)

1, Flower 2, Fruit. 3, Fruit, without hairs.

but a member of the Sedge order (Cyperaceæ). The plant is perennial, and has a stout rootstock, from which three-cornered stems about 1 ft. high ascend into the air. Most of the leaves are down at the ground; the apical half of the leaf-blade is very characteristic, for instead of being flat it is triangular. The flower consists of many bristles (instead of a calyx and corolla), three stamens, and a three-sided and one-ovuled ovary, with one apical style ending in three stigmas. These flowers are grouped together into spikelets, and each flower of the spikelet is subtended and protected by its own thin brown-coloured bract (usually called *glume*). The spikelet is cylindrical and of egg-shaped outline, ½ in. long, and provided with a long stalk. Five or six of these stalked spikelets are grouped together in the form of an umbel at the end of each fertile shoot. When the spikelet is in flower, the bristles are completely hidden; the anthers and the stigmas alone project. But when fertilization has been accomplished the bristles begin to project, and become ultimately over 1 in. in length. The three-sided ovary at the same time becomes a tiny three-sided nut. The white colour of the numerous and now projecting bristles makes the Cotton Grass a most conspicuous feature of wet peat-moor vegetation in the months of May and June. As yet, no use has been made of these cottony hairs.

Other species of Cotton Grass occur, which are distinguished from the narrow-leaved species by the circumstance that each fertile stem bears but one solitary spikelet. Such is the Hare's-tail Cotton Grass (*Eriophorum vaginatum*), which is also conspicuous on wet moors in the early months of the year. [A. N. M'A.]

Couch Grass. — Couch Grass or Twitch (*Triticum repens*) is a perennial and pestilent



Couch Grass (*Triticum repens*)

1, Floret. 2, Fruit. 3, Nectary. 4, Portion of a leaf. 5, Base of leaf. 6, Base of leaf of Bent Grass (*Agrostis vulgaris*).

weed of light land, not nearly so troublesome, however, nor so prevalent as the Common Bent Grass (*Agrostis vulgaris*). The perennating apparatus of Couch is a creeping stem,

which lengthens and branches extensively underground. From this stem green shoots grow up into the light and air, for the express purpose of manufacturing food for the underground establishment. One can easily understand why the leaves of these air shoots are not eaten by the browsing stock: there is little nourishment in them, for most of the nutritive substance has been passed on to the underground stem, and besides, they are too rough and hairy to be palatable Couch further is less prevalent than Bent Grass because the creeping stem of Bent has the power of adapting its depth in the soil to the circumstances of the case, going deeper down in light dry lands, and growing more towards the surface whenever the land becomes heavy or wet. It is not so with Couch—its underground stem wants the adaptability so well marked in Bent. From the underground stem, roots grow down into the depths of the soil to exploit there the water and the minerals.

An instant's consideration of the mode of growth of Couch shows that the eradication of such a weed from light land, which specially suits extensive underground growth in a horizontal direction, must be a matter of considerable difficulty. Horizontal growth at some depth in the soil makes the difficulty of pulling great, and we can hardly hope to pull up the plant completely—fragments will assuredly be left behind in the land.

Again, if we plough or harrow, unpulled fragments will be left behind. If we gather together the pieces of Couch pulled or harrowed out, cart them to the farm, mix them with the dung and return them to the land, we are merely propagating the Couch Grass. Hence one important point connected with the eradication of Couch is the use of clean dung—free, at any rate, from pieces of Couch.

Consider now what happens to any fragment of Couch left behind in the land. The piece is a bit of stem with all the stuffs for making roots and shoots stowed away and ready for use. Any such fragment of Couch is thus a propagating machine, and one perfectly adapted for propagating purposes.

It is a simple matter to distinguish a shoot of Couch from that of any other grass. The first point to notice is that the Couch shoot is hairy, whereas Bent Grass is never hairy. The next point to notice is the base of the leaf-blade, where it joins the sheath. There a pair of fine hooklike ears are readily seen; no such ears occur on Bent Grass. While examining the ears, one observes also the absence, or rather the rudimentary nature, of the membrane which is called *ligule*. In Bent and other grasses this ligule is quite conspicuous, but it is not so in Couch. Any hairy grass, then, with hook ears and rudimentary ligule means Couch. It is indeed surprising how it comes to pass that learned men accustomed to look at grasses confound things so easily distinguished as a shoot of Couch and a shoot of Bent.

When one examines any old pasture and looks for Couch, even on light land, one scarcely ever finds it, although Bent occurs in abundance. This gives us a significant hint regarding Couch eradication. When land is laid under grass for three or four years, the roots of the grasses occupy very completely the soil above the underground stem of Couch, and any nitrates formed in the surface soil are snapped up and so completely absorbed that the Couch roots cannot get them. This deprivation continued for some years may well lead to the death and destruction of the Couch weed.

When growing luxuriantly the ear-bearing straw of Couch may reach a height of 3 ft. The ear closely resembles that of Rye Grass. It has a simple unbranched axis, which bears two rows of spikelets; in the case of Couch, these spikelets are set on with the flat face next the axis, whereas in Rye Grass the spikelets are edge on.

[A. N. M'A.]

Coughs.—A cough indicates irritation in some part of the breathing apparatus, the seat of which may be as far distant as the larynx from the pleural coverings of the lungs A so-called stomach cough is a sympathetic irritation, by what is known as reflex action from branches of a common trunk of nerve, some of which may serve the gastric and others the respiratory organs. The pneumogastric nerve is most commonly concerned. The cough, or the whistling or roaring of horses with chronic laryngeal trouble, is due to some undefined interference with the functions of the left recurrent nerve. A cough should never be treated lightly in a horse, because it may lead to chronic cough or to broken wind. In ruminants it should be regarded with suspicion, as possibly indicating tuberculosis or other grave affection. Coughing is a natural effort to expel its causes, and in many instances affords relief; in others it is but a futile attempt, resulting in still greater distress to the subject of it. At one end of the scale we have the whooping cough of the infant and the husk of the calf, which induce exhaustion, and at the other the well-directed efforts of the asthmatic among men and dogs; only that the latter fail to expectorate, and need emetics to expel the swallowed products of chronic cough. Both dogs and pigs derive much relief from judiciously administered emetics, when there is no food in the stomach. Cough in young animals may arise from the presence of worms, as those of the bronchi, giving rise to husk or hoose (see HUSK), or in connection with the stomach and digestive tract, and are generally of the round varieties, as the ascarides in pigs, dogs, and cats, or the 'strongles' in horses and ruminants.

Cough is a common symptom of catarrh; often a secondary one; sometimes a preliminary symptom, according to the structures specially involved. The cough of laryngitis may be so painful that a horse will desire to give vent to it, but suppress the action, being 'too sore to cough' as observant horsemen say (see LARYNGITIS). In the early stage of pleurisy there is somewhat the same difficulty, the setting of the ribs and diaphragm giving rise to so much pain that coughing is performed with extreme reluctance. Cold, dust, irritating gases, bad air (as in stables with free ammonia), excite cough which may prove temporary or become chronic.

Coughs have a particular character which to some extent is diagnostic of the region affected. The long, soft cough of broken wind and the soft, husking cough of tuberculosis are in contrast with the hard, painful, 'tearing' cough of laryngitis or the occasional cough of parasitism or dental difficulties in the young. Enough, perhaps, has been said to direct the reader's attention to the cause of the particular cough with which he may have to deal, and without an intelligent appreciation of the cause he will be at a disadvantage in attempting any treatment. Sedatives and counter-irritation may be indicated in one case; worm medicines and purgatives in another. [H. L.]

Coulter. See PLOUGH.

Cow.—It would be invidious to choose any one breed of cows, out of the many the world possesses, and call it the best of all, when there are so many that are excellent. Were such a choice made, indeed, it would not command universal consent. Some breeds—those of the Channel Islands by way of illustration — are specialized producers of milk, in quantity as well as in quality. Others — say the West Highlanders—are famous as growers of beef whose quality cannot be surpassed. And yet others —the Shorthorns—are universally regarded as excellent 'all-round' cattle for beef and milk combined. It is notable that three of the best milking breeds, indigenous to the British Islands, are the three smallest in size— the Jerseys, the Ayrshires, and the Kerrys. The first and last yield, for their size, a large quantity of milk whose quality is above that of most other milks, whilst the second yields a very large quantity whose quality is quite an average.

It is worthy of note that the milk-yielding capacity of breeds of cows is for the most part, as we know it now, a natural function artificially developed. It is true, however, that environment—climate, locality, herbage—has been a potent influence in the lacteal evolution of such breeds as the Jerseys, Guernseys, Ayrshires, and Holsteins. Generally speaking, the breeds that yield the richest milk are those of genial climates and generous soils. Conspicuous illustrations of this are seen in the Jerseys and the Kerrys, which, in respect to quality of milk and to relative quantity of it, are regarded as being in a very short front rank of all breeds of dairy cows in the British Islands or elsewhere. On the other side of the question, and in respect to large milk yields of average quality, the Ayrshires are the best exemplars, as are the Holsteins of great quantity of milk of somewhat inferior quality.

In regard to the two breeds last named, the large milk yields for which they are distinguished is a problem yet unsolved, save on the hypothesis of natural tendency in that direction, which has been most assiduously cultivated during a long period by the Scotch and the Dutch peoples. It is less hypothetical that climate in both cases has interfered with the question of heredity in respect to milk of high quality, such as that of the Jerseys, the Guernseys, the Devons, the Kerrys, all southern breeds favoured by genial climatic conditions. The demand of a rigorous climate, as compared with a genial one, reduces the amount of fat available for making rich milk, in order to maintain the warmth of the cow's body, and hence it is that in severe weather the yield of butter is diminished. The inference suggests that a breed of cows in Holland or in Ayrshire is not likely to develop a propensity for elaborating milk as rich as that of breeds in milder climates, even though there is nothing to choose in regard to soil fertility. It follows, too, in accord with the laws which influence animal reproduction, that in course of time all the bodily functions accommodate themselves to their environment, and milk-yielding in respect to quality becomes hereditary like anything else.

So far as we can decide on the question, the quality of milk yielded by cows depends more on breed than on feed, more on heredity than on new surroundings, more on inherent functional capacity than on any other advantages recently acquired. The quantity of milk may, on the other hand, be influenced, and commonly is influenced, by improved food, by shelter, by kind treatment. It cannot be denied that kindness bestowed on cows, especially when habitual and prolonged, has a marked influence on the yield of milk — in quality to some extent, in quantity most of all. Cows indeed, being ruminants, are as a rule readily and speedily responsive to generous food and kindly treatment. A cow in milk is, if she is encouraged to follow her bent, a placid, meditative, languid animal when at rest, and this is a frame of mind apparently necessary to the production of a maximum quantity of milk rich in its most valuable ingredient, viz. butter fat.

Cows that are starved of food, chased about by dogs, or flies, or men, exposed to nipping frosts and gales of biting wind, or are otherwise despitefully ill-treated, will yield milk less in quantity and poorer in quality than if they had lived under happier conditions. All this is fundamentally true, but it is too commonly lost sight of in practice amongst dairy farmers, and always to their hurt and disadvantage, though many of them fail to see it. In the fall of the year, for instance, milch cows are commonly kept out on the land day and night, when —at all events at night—they ought to be in the sheds. During the dark, cold nights of the fall and of early winter, cattle can only lie about on the land, if they are still left out, finding what precarious shelter they can under the lee of fences. They just lie there, patiently, passively waiting for morning. Why, therefore, are they not allowed to lie, warm and dry, in the sheds, even if they are not fed indoors? The only reason current is that they fall away in milk once they are housed at night. This popular fallacy dies but slowly.

During the lapse of centuries, dairy cows have grown accustomed in our British climate to be artificially fed and sheltered during half the year—the winter half; and it is an actual second nature with them to expect this sort of treatment whenever it is needed. Domestication is not achieved in one generation, or in two, of cows; nor can it be discarded with impunity

once it has become habitual with the animal. It is not too much to say that many cattle die in consequence of exposure to wet and cold. These agents, especially when combined, develop diseases that are merely incipient. Debility and enfeeblement, caused by exposure to bad weather, signify a run-down condition that promotes disease and invites the germs that start it.

It is also to be observed that copious milking, as a function, enforces a hard drain on the vitality of a cow, and this again renders her subject to some of the numerous ills that bovine flesh is heir to. This function, indeed, developed as it is by hand-milking and domestication, is in itself a potential cause of weakness, and necessitates precautions as to shelter in trying weather, and as to suitable food as well, when the year is waning. 'The merciful man is merciful to his beast.'

To the practised eye there are several indications of milky tendency, or the opposite, in dairy cows; that is to say, in cows of the recognized dairy breeds. As a general rule, the more such indications in the dairy breeds approximate to what we observe in the non-dairy breeds the less expectation may we indulge in of a copious flow of milk. There are no breeds of cows, ancient or modern, of which we have cognizance, that possess more essentially typical indications of milkiness than the Jerseys of southern England and the Ayrshires of southern Scotland—none, indeed, that come very close to them in that respect. With fine, vertically narrow fore quarters, and broad, spacious hind quarters, they are not brick-, but wedge-shaped. Along with refined, feminine countenances, their hair is for the most part smoothly laid and flat on the skin, which itself, fine and tough to the touch, is not too generously supplied with subcutaneous tissue.

A system or theory, bearing the name of 'Guenon', a French scientific observer, attracted considerable attention a generation ago. The system sought to indicate the capability for milk of cows whose hair, surmounting the udder between the thighs, formed what was termed an 'escutcheon'. The hair of this 'escutcheon', instead of sloping downward, as one would expect, slopes upward and outward. And when the escutcheon is large, broad, well developed, the cow promises to be a good milker. But if the reversed hair occupies but a small space below, and is narrow and irregular above, the cow is not promising for milk. This theory is plausible, inasmuch as there is a good deal of truth in its interpretation of a natural phenomenon. It is, however, not infallible, and indeed does not pretend to be. It is a guide, and as such, used moderately, will be found useful, interesting, instructive, but not absolute. See also Guenon System, and Cows, Management of, &c. [J. P. S.]

Cowbane, or **Water Hemlock** (*Cicuta virosa*), is a deadly marsh plant of the order Umbelliferæ. It is a bald perennial found growing in wet places by the sides of ponds and ditches. When the plant is pulled out of the ground it shows a characteristic rootstock. This stock is vertical, large, white, and fleshy, and might be mistaken for a small turnip. When cut lengthways the characteristic feature is seen—the stock is hollow, with transverse partitions, and a yellowish milky juice oozes out of the cut surface. The air stem is erect, also hollow, and 3 or 4 ft. high. The large leaves are characteristic—they are cut up into many segments: the segment is 1 or 1½ in. long, shaped like a lance, and toothed on the edge. The flowers are small and white, arranged in large compound umbels. The fruit is also characteristic—it is only $\frac{1}{10}$ in. broad, and the length is still less; it is a two-lobed body, crowned at the apex with five little

Cowbane, or Water Hemlock (*Cicuta virosa*)

1, Flower. 2, Fruit. 3, Section of fruit

teeth (sepals), and within the teeth there are two slender styles which curve outwards and backwards. Men are known to have been poisoned by eating the fleshy rootstock, and many cases of cattle poisoning have also occurred. It is said that sheep and goats are not affected by the Cowbane poison. [A. N. M'A.]

Cowberry, or **Red Whortleberry** (*Vaccinium Vitis-idæa*), belongs to the order of dicotyledonous plants called Vacciniaceæ, of which the distinctive marks are: (1) The petals are grown together. (2) The ovary is on the outside of the flower. (3) The stamens are twice as many as the petals, and inserted on the top of the ovary. The Cowberry is a trailing evergreen shrub of dry rocky moors and heaths, with flesh-coloured bells on their flowers. The fruits are red berries closely resembling Cranberries, for which they are sometimes sold. [A. N. M'A.]

Cow Grass. See Clovers.

Cow House. See Byre.

Cow Pox. See Pustulation.

Cows, Bowing of. See Bowing.

Cows, Management and Feeding of Dairy.—This subject may conveniently be divided into sections dealing with the two classes of cows, viz. those giving milk, and those giving no milk, but in calf; the management and feeding of these classes respectively being then dealt with, under consideration of what is desirable for either summer or winter.

The Summer Treatment of In-calf Cows.—If not already dry, these should be put dry at from one to two months prior to the date when they are due to calve. The majority of cows become dry earlier than is wanted, but a few continue to give milk longer than it is desirable that they should, as when cows are milked for an excessively long period there is a tendency in the calf to be undersized, and the cow to be thinner than she should be. An attempt should be made to have all such cows quite dry before they are put to grass in spring, as when put on fresh pasture there is a strong tendency in the flow of milk to increase, and further delay the date of drying off. When it is desired to dry off a cow because of the near approach of her time of calving, milking once a day should be resorted to; and while the most of the milk may be taken away the first time or two, less should be withdrawn each time, until the quantity yielded is so reduced that it is not necessary to withdraw it oftener than once in one and a half or two days. As a rule, most cows will at this stage very soon become quite dry; but as long as any milk is produced it should in whole or in part be withdrawn every second or third day, and as the end is reached it is better to entirely empty the udder. If much is allowed to gather at the end, there is always some risk of mammitis (or inflammation of the udder) setting in, or of the quarter showing more or less weakness when the cow next calves.

While cows are all the better for being fairly well fed when carrying their calves, they should not be richly fed when approaching parturition. More especially is this the case when they are on pasture, as if the grass is at all succulent and plentiful, and the cows are in middle life and full milkers, there is almost certain to be considerable loss from what is called milk fever or the 'drop' after calving. In order to guard against this loss, cows which are near their time of calving should be kept on rather bare pasture, and even under these circumstances should be brought into the house a week or ten days prior to calving. If this is done, and when in the house they are fed on a little hay and bran and treacle, the loss from this cause will be reduced to a minimum. When it does occur, as it will occasionally do, even with the most rigid precautions, if the cows are heavy-milking ones, every stock-owner should be provided with an apparatus for the injection of sterilized air into the udder on the first symptoms of the disease. This apparatus, and more especially the needle or tube for insertion in the teat, must be kept absolutely clean and free from contamination; otherwise, while the life of the cow may be saved, its udder in whole, or in part, will be lost by mammitis. In order to guard against this, the needle or tube should, before use, be sterilized by dipping in boiling water, and the air which is injected into the udder should be as pure as possible. If these precautions be taken, there will be few losses and little trouble with bad quarters.

The Winter Treatment of In-calf Cows.—In winter the cows should be housed in freely ventilated buildings, and in all ordinary weathers should be turned out daily for a drink, fresh air, and more or less exercise. The length of time they are outside should be varied according to the state of the weather. In mild, calm weather they may be allowed to stay out an hour or two even in midwinter, but in rough, cold, or wet weather the time they are outside may with advantage be reduced to an hour or less. Cows so treated, and judiciously fed, invariably produce larger and more healthy calves than where they are kept constantly in the house.

Their food should be largely made up of hay, straw, and turnips. In many of the rearing districts straw is scarce, and few turnips are available, the bulk of the fodder being hay. If, in sufficient quantity and of good quality, no single substance will serve the purpose so well. Where roots are scarce, or where the whole or a portion of the fodder is oat straw, or where the hay is not first-class, 2 or 3 lb. of linseed cake may with advantage be given to each animal daily. Where the home-grown foods are deficient in quantity or quality, almost any concentrated food, if judiciously used, may advantageously be fed along with them. No single substance has, however, given such uniformly good results as linseed cake, and more especially where roots are scarce, or awanting, it is questionable if anything better can be used.

It is a very common belief that if decorticated cotton is fed to in-calf cows, it is almost certain to have a detrimental effect on the health of the calves, and that the death-rate among them will be heavy. This has not, however, been invariably the case, as some rearers have used it for years quite successfully, so that the unfortunate results of others may be the effect of injudicious use of the cake, or of some other food. If very dry fodder is freely used, and few or no turnips are available, the cows should be freely supplied with water. Any of the systems by which water is constantly, or at intervals, put before every animal, is to be preferred to restricting them to one big drink of very cold water daily.

The amount of food necessary for an in-calf cow will in great part depend on the size of the cow and the quality of the food. The average cow of any of the moderate-sized breeds will, however, consume daily from 8 to 10 lb. hay, and from 20 to 30 lb. of turnips, or their equivalent. If the cows are larger than the average, or the food indifferent in quality, or insufficient in amount, it should then be supplemented by linseed cake or other concentrated feedingstuff.

The Summer Treatment of Cows in Milk.—In early spring, cows are usually put out to the

pastures before there is sufficient grass to supply them with food, so that the pasture has for a time to be supplemented with something else. At that period the cows are usually in the house at night, and if plenty of hay is available, few foods are so cheap, and scarcely any are more satisfactory. New grass has generally a very laxative effect on the cows, and if at first they are restricted to it alone, it often has a bad effect on them. Until the pasture becomes firmer, or loses its laxative effect, or the animals become accustomed to it, some dry and rather binding food can always be given them with advantage. Hay is probably the cheapest food of any of those most generally useful for this purpose, while of the concentrated foods none has greater effect than cotton cake, either undecorticated or decorticated. Most others may, however, be used with advantage, although few of them are to be preferred to those just specified.

When cows in milk are on the pastures both night and day their treatment is very simple, as it resolves itself into seeing that they have sufficient food and water, and that they are thoroughly milked and mated at the proper time. If the grass is very succulent, the cows should be encouraged to eat some dry and binding food. This, however, is at times rather difficult to bring about, since when concentrated food has once been stopped, and pasture is plentiful, there is often great difficulty in getting the cows to take any concentrated food again at all. If, however, a little is put before them constantly at milking time, it is wonderful how much they can be induced to eat. If the number of stock is too great for the available amount of pasture, extra food should always be given. It should, however, be always kept prominently in mind that few if any foods are so cheap as pasture, and extra foods such as cakes or meals will rarely increase the quantity of milk or its quality to such an extent as is likely to pay for their cost, although their use may help to keep the animals in better bodily condition.

The Winter Feeding of Cows in Milk.—It is generally accepted as an undisputed fact that all cows require an amount of food, (1) in proportion to their size, and (2) in proportion to the amount of milk they give. If a cow of a certain size can keep up her weight on say 6 to 8 lb. hay, and from 25 to 30 lb. turnips daily, the same cow will require about 3 lb. of mixed meals or cakes daily, and a little hay and turnips extra for every gallon of milk yielded by her. In full milk, the daily ration should consist of about 10 lb. hay, 5 lb. oat straw, 30 to 40 lb. roots, and from 8 to 10 lb. mixed meals, cakes, and bran.

In the production of milk in winter the outlay necessary for food is much greater than in summer. In the milk record societies in the south-west of Scotland, at intervals of a few years, a note has been kept of the rental of all lands on which the cows graze. According to district, quality of land, &c., the rental varies greatly, but the cost of grazing a cow during the summer differs very little. It has been found that in most districts with cows in full milk, the outlay necessary for pasture alone to produce a gallon of milk runs off and on about 1½*d.* per gal., reckoned over the whole grazing season. In winter, even where the home-grown foods used are in fairly large proportion, and the cows get from 8 to 10 lb. of purchased cakes, meals, &c., daily, the outlay on the same farms for food alone runs up to from 4*d.* to 4½*d.* per gal., a large proportion of the farms being near the latter figure. The expense of attending the cows is much greater in winter than in summer, and although the value of the milk is also greater, it is only in isolated cases that in winter a proportionately high value is obtained compared with the cost of production. All evidence seems to indicate that at present rents the cheapest food is pasture, and that next to it comes hay, oat straw, and roots, used in judicious amounts.

In many districts a great deal is made of the advantage likely to be obtained by using particular concentrated foods, such as beans, peas, &c. Every district has its own favourite substance, but experience seems to indicate that there is no great superiority in any single food, but that the best results are likely to be obtained from a carefully blended mixture. Foods rich in protein, such as cotton cake, decorticated cotton-seed meal, beans, peas, gluten meal, linseed cake, &c., are all in request in particular districts; but other than the food ingredients which they contain, none of them have any specific value for the production of milk, such as is often attributed to them. Brewery or distillery grains seem, however, to be an exception, and to have a distinct effect in the direction of increased production of milk; indeed with them the tendency to an increase is quite pronounced.

Leaving strong-smelling and otherwise objectionable foods out of account, there are a considerable number which impart some distinct characteristic to the milk, or to the butter and cheese made from it. As a rule, this characteristic only becomes pronounced when the food is used in excess, or, it may be, injudiciously. When turnips are fed in large quantities they are apt to cause the milk to have the flavour of turnips, and if there are leaves or young growths on them the flavour is usually more pronounced. To some extent cabbages have the same tendency, and with them it becomes intensified if decay has set in among the leaves. Cotton-seed meal has a hardening effect on the melting-point of butter, while gluten and maize meal make it soft. Linseed cake with much oil in it, favours the production of what is known as greasy butter. The churning temperature of milk or cream in the production of which cotton-seed meal or the young growths of heather have been used, must be considerably raised, otherwise it will not be possible to get the butter to come in the usual time. Paisley meal and gluten meal, both of which are maize meal with a portion of the starch extracted, have the reverse effect, and where they are freely used, the churning temperature should be kept lower than usual. Oats have the credit of giving one of the most desired of

all flavours. Much the same results are obtained in the feeding of pigs; as in the production of pork of the best quality,—possessing firmness and flavour combined—skim milk, whey, and barley meal invariably give the very best results, while maize meal, gluten, and Paisley meal produce a very indifferent quality.

The preparation of the food given to cows is an important matter, and one on which there is much more difference of opinion among milk producers than is generally known. Many think that if any operation of the farm could be carried out in the same way in different districts it should be that of feeding cows, especially in those districts where the home-grown foods are the same. Such uniformity, however, does not exist. In the use of roots, for instance, some farmers pulp or slice them all, while others feed them whole. With old cows that have bad mouths, from which some of the teeth are awanting, there is little room as to difference of opinion in regard to the economy of the practice of pulping or slicing, but with younger animals it is very doubtful if a sufficient return is obtained for the labour expended. This much is certain, that if the animals can eat the roots whole in a reasonable time and with ordinary comfort, a given weight will supply no more food ingredients in the sliced or pulped stage than whole.

Where it is desired to feed meals of any kind, and a supply of roots is available which can be pulped, no better or more safe method exists of using them, than mixing the two together. Where the power is constantly at hand, the pulping may be done twice a day, sufficient being done at one time to serve the stock for one feed. If the power is only available at one time of the day, sufficient may be pulped for one day's requirements. If a quantity of cut straw can be mixed with the pulped roots, it is an advantage to do so. This straw should not be cut excessively short, since when it is cut moderately long, remastication is much more likely to be done effectively than when it is very short. The meal, straw, and pulped roots should be thoroughly mixed, and should lie in a heap for twenty-four hours before use. If this is done, the straw and meal are softened by the juice of the roots, division of the particles is more effective, and the digestive juices having access to every particle, digestion is likely to be more thorough than where this is not done. Meal so treated will be in much the same condition as if it had been saturated with hot or cold water, while the whole mass will have attained such a degree of fermentation that the temperature will have risen to about blood heat.

In the dairying districts of the south-west of Scotland it used to be considered that the best results could not be obtained unless the meal was boiled or scalded. Not only was the meal treated in this way, but cut hay or straw, chaff, and even turnips, were boiled. Later experience seems, however, to indicate that such treatment in the majority of cases is quite unnecessary, and that equally good results may be obtained from saturating the cut straw or meals with either hot or cold water, provided the mixture is raised to the temperature of blood heat before being fed to the animals. [J. S.]

Cowslip (*Primula veris*), one of the several species which grow wild in the meadows and hedgebanks in the British Islands. Wild hybrids between it and the primrose occur; it has also been used in breeding the garden race known as Polyanthus (which see). Although too common in English meadows to be worth growing as a garden plant, yet the Cowslip is sufficiently decorative to deserve a place in gardens in districts where it does not occur wild. It is easily raised from seeds, flowering when about a year old. [W. W.]

Cow-wheat. See Melampyrum.

Cracked Heels.—If the finger is lightly rubbed in the hollow of a healthy horse's heel, it will be found to have a slightly unctuous material upon it. This is secreted by minute glands arranged in the flexure to prevent friction when the limb is flexed. Cracked heels originate in an inflamed condition of these glands. Extremes of heat and cold, snow in winter and dust in summer, washing the legs or watering farm horses in ponds, where they dally long enough to get chilled, are among the causes; but in certain conformations there is a predisposition to cracked heels which may be called constitutional. The flat-sided and shallow-chested belong to this class. Before a crack is developed there is acute inflammation, and fluid forms between the skin and subjacent tissues. A horse in this condition will appear to his attendant in the morning as so acutely lame, that he thinks a bone is broken or some serious accident has happened in the night. On being compelled to move, the suffering member seems incapable of taking any weight, but with a few steps a crack in the skin releases the pent-up fluid, and immediate relief is obtained. The animal, if put to work, will probably go sound until again rested and the opportunity afforded of uniting, merely to fill again and be as bad next morning.

Treatment should be adopted at once. A poultice put on the heel; a mild saline, as 4 oz. of salts and 1 oz. of nitre given in a mash; and next day the poultice removed in favour of a dressing with such an emollient as 1 oz. of Goulard's extract in 7 or 8 oz. of linseed or olive oil. A few minutes' walking exercise twice a day is desirable, as the crack should not be healed until the disposition to re-form fluid has passed away. A union that is too quickly formed may not only imprison matter, but readily give way when but little strain is put upon it, and then a chronic crack or long fissure of an ulcerated type will need more drastic treatment, the indolent nature of which must be overcome by touching up with a crystal of sulphate of copper, or a lotion of zinc sulphate applied with a brush, or stick nitrate of silver; but the latter stains a white heel. Summer cracks are often better treated by first washing with yellow soap and warm water, then wiping dry, and dusting over with 1 part boracic acid and 9 parts of starch powder or wheat flour. Horses disposed to cracked heels should have the heels dressed with

zinc ointment, to each ounce of which 10 drops of carbolic acid has been added. This ointment is useful for many simple cases where the animal may be kept at work. [H. L.]

Crambe, a genus of perennial herbs with thick fleshy roots, large succulent leaves, and tall corymbose racemes of white flowers similar to those of the cabbage tribe, to which it is related. The best-known species is *C. maritima*, the Sea-kale, a native of the British Islands, where it grows on sandy and shingly sea coasts. It is largely cultivated for its blanched young leaves. For culture see under SEA-KALE. Several species are grown as decorative plants, namely *C. cordifolia*, *C. orientalis*, *C. pinnatifida*, and *C. tataria*. They are all as easily grown as the Sea-kale. [W. W.]

Cramming Machine.—Where the fattening of poultry is carried out upon a large

Cramming Machine

scale, the question of labour becomes of considerable importance, and whatever will help in minimizing that labour is essential to success. Particulars with regard to the system of fattening are given elsewhere (see POULTRY FATTENING). For at least 4000 years, fowls have been crammed by hand, that is, at certain stages of the process of fattening, pellets have been forced down their throats in order to fill the crop. That, however, is a somewhat slow process, and machines are now employed for doing the work. In the middle of last century this system was introduced in Sussex, but the apparatus then used was very crude in form, and great improvements have since taken place. In France also this system is adopted, although the machines differ considerably from our own.

The cramming machine which is largely used is that represented in the illustration made by Messrs. C. Hearson & Co., of Regent Street, London, W. It consists of, first, a food reservoir, holding a supply for a couple of hundred birds; second, a force pump immediately below the reservoir. As the pump is operated and the food forced from it, a further supply passes in for the next operation. On one side of this force pump is a small pipe through which the food passes, and attached to that is either a long indiarubber tube or in some cases a tube made of fine leather. The former, however, is to be preferred, as it is less likely to hurt the throat of the fowl. The third part of the cramming machine is a piston rod in the force pump, attached to a foot lever, so that the operator, by the pressure of his foot in working the machine, can pass a succession of supplies of food out by means of the nozzle and tube already referred to. The machine is placed upon a fixed wooden tripod, to which are attached wheels so that it can be moved about very easily. When in operation the bird is taken, the mouth is opened, the head stretched out until the neck is straight, when the tube is inserted in the mouth, keeping the tongue on the under side. The operator then draws the head of the bird on to the tube until he feels that its end is in the crop, when by pressure of the foot he is able to fill the crop. Care has to be taken, of course, not to force too much food into the crop or it may burst. [E. B.]

Cramp in Pigs.—Pigs are specially subject to muscular cramps, which come on suddenly and are very painful, as swimmers know well, and writers, who were incapacitated frequently before the advent of the typewriting machine. Many persons escape almost entirely from these painful cramps; and so with the lower animals it would seem to be peculiar to families, and every care should be exercised to breed it out by retaining neither boar nor sow pig for stock in whose family the malady has been observed. The cramped circumstances in which pigs are commonly kept contribute, no doubt, to the causes; but it is primarily a nervous affection, the nerves governing the muscles acting in a manner to throw certain of them into spasm, which may be compared to the spasm of the muscular layers of the intestine, which we know as spasmodic colic. Cramp of a less severe type, and merely due to remaining in one attitude too long, thereby interrupting the circulation of the blood, gives rise to those conditions known to ourselves as 'pins and needles', when the blood stream is resuming its wonted force; and the disposition to more severe attacks in pigs would seem to begin in this way, when in the long winter nights they lay huddled together for the sake of warmth, and upon damp beds. Their indisposition to turn out into the cold leads to long retention of urine, and it is thought by some of the best pig-keepers that absorption of the contents of the bladder into the general circulation is an active cause of cramp. Persons holding this view make a practice of stirring up the litter in the late evening,

when the pigs take the opportunity of urinating, with good results. Feeding on food of too stimulating a nature, as maize and bean meal, appears to cause cramp, as does constipation. The circumstances in which cramp is developed point to the retention within the system of waste products which should be eliminated by the liver, kidneys, and skin, and the most successful treatment is that of purging, lowering the ration, and gently exciting the liver and kidneys by the administration of salines. Castor oil in doses suited to the age, followed by Epsom salts, and nitrate of potash in small but repeated quantities, are found to have the best effect. Temporary relief is given by rubbing with warm liniments. Joint evil is often misnamed cramp in its early stages. [H. L.]

Crane Flies. See TIPULA and GRUB.

Craonais Pig.—The best specimens of this breed are to be found in the environments of the little town of Craon, in the French province of Mayenne. Pigs of this breed are noted for their large size, for the excellent quality of their flesh, and for their large proportion of lean meat. They come early to maturity, and are ready to kill any time after the age of one year without the flesh losing anything of its fine flavour, in which respect they surpass many of our English breeds. When full grown and fat, the Craonais pig weighs about 6 cwt. (live weight). The body is long, thick, and almost cylindrical, and covered with fine silky hair; the ears large and drooping; the snout long and broad but not turned up. The legs are short, and the hams exceptionally well developed. The female litters twice in the year, and the young pigs usually fetch 17*s.* 6*d.* a head. On account of the fine quality of its flesh, the Craonais pig is greatly sought after by the pork butchers of Paris.

Crassula, a large genus of succulent plants occurring chiefly in South Africa; some of the species are cultivated in gardens as ornamental plants for conservatories and for summer bedding. They all grow freely under ordinary treatment, and are easily propagated from cuttings. The best known are *C. pallida* and *C. falcata*, the former with white, the latter with red flowers, arranged in a large flat head on the apex of the stem. The plant known in some gardens as *C. coccinea*, which has decussate leaves and umbels of bright-red flowers, is properly a Rochea. It is very common as a window plant in some towns near the sea. *C. jasminea* is a dwarf plant of the same character as the last-named, but the flowers are white and smaller. [W. W.]

Cream.—Cream is the name given to the lighter portion of milk, being that which rises to the surface when the milk is allowed to stand, or which can be otherwise separated by centrifugal force from untreated milk. It contains a much higher percentage of fat than milk, the other constituents being correspondingly lower; a certain concentration also often takes place, due to evaporation of water. The fat globules are in suspension as in milk, and are surrounded in all probability by some of the nitrogenous and other constituents of the milk by the surface attraction of the globules.

Cream rises very slowly from milk which has been heated; but if the milk has not been heated its richness in cream may be roughly estimated by setting it in a glass tube or cylinder the top quarter of which is graduated in volumes each equal to $\frac{1}{100}$th of the whole vessel (which is known as a 'creamometer'). The percentage of cream can be read off after standing six hours or more.

The following figures given by Richmond show the rate at which cream rises Well-mixed milk having a fat content of 3·73 per cent was placed in vessels having a depth of 24 in. The fat was determined at different depths, after the vessels had stood for varying times, as follows:—

PERCENTAGE OF FAT AT DIFFERENT DEPTHS

	Bottom inch.	18 in from top	12 in from top.	6 in. from top	Depth of cream	Per cent fat in cream.
40 min.	2·80	3·45	3·55	3·60	?	11·0
1 hr. 35 min. .. .	2·35	2·90	2·98	2·90	2·09″	12·6
2 hr. 30 min.	1·95	2·65	2·72	2·75	2·09″	14·2
3 hr. 30 min.	1·42	2·62	2·72	2·75	2·05″	15·2
4 hr. 30 min.	1·30	2 58	2·62	2·68	1·97″	16·2
5 hr. 30 min.	1·20	2·55	2·58	2·62	1·89″	16·8
7 hr. 30 min.	0·90	2·52	2·53	2·55	1·93″	18·2
24 hr.	0·23	1·88	1·90	1·90	1·89″	23·5

Cream used always to be obtained by setting the milk in pans, allowing these to stand for a time, and then skimming off the cream; but in large dairies, and even in many farmhouses, this method has been to a great extent superseded by the use of separators, which have the advantage of separating the cream from the other constituents of the milk as it runs through the separator. The short time in which the operation is conducted prevents the contamination of the cream with micro-organisms from the air; the centrifugal force also cleans the milk and cream, throwing out any dirt or solid matter in the form of a slime which sticks to the inside of the drum of the separator; and last but not least, the separation of the cream is much more complete, skim milk usually containing more than 0·4 per cent fat, while separated milk only contains 0·1 to 0·2 per cent of fat.

The percentage of fat in cream varies very much, but this is not to be wondered at, as there are many ways of preparing cream. From the

separator either a thick cream or a thin cream may be obtained. Skimming may give cream of varying richness in fat. There are also various other methods of preparing cream; for example, the clotted cream of Devonshire and Cornwall is prepared by scalding the pan of milk on which the cream has risen, before skimming it off. After scalding, the pan is allowed to cool before skimming, and the resulting cream is almost solid.

The richness of cream is often judged by its thickness, a criterion which is often misleading, and has led to the artificial thickening of cream by the addition of various adulterants. Among these may be mentioned the following substances: gelatine, starch mucilage, and a solution of lime in cane-sugar syrup which goes by the name of 'viscogen'.

The analysis of cream, if very thin, can be conducted much in the same way as in the case of milk, but as a general rule the cream has to be first diluted. This is generally done with an equal weight of separated milk. If the density is determined with a lactometer in such a dilution, the original specific gravity of the cream before dilution is calculated by multiplying the specific gravity of the separated milk by the specific gravity of the mixture, and dividing the result by the difference between twice the gravity of the separated milk and the gravity of the mixture.

The fat may be estimated in the 'Gerber' method in the diluted cream, but as the butyrometer is only marked for 9 per cent fat, a still smaller quantity must be taken. The most convenient quantity for calculation is one-third of 11 c.c. (3·67 c.c.) of the mixture, and 7·34 c.c. of water; the percentage of fat obtained on the scale must be multiplied by 6, as only one-sixth of the original cream has been taken. The fat may also be determined by the Werner-Schmid or by the Gottlieb-Rose methods. The original cream should be weighed into the tubes. The total solids should be determined as in milk, but if an equal volume of alcohol is first added no skin is formed on the surface, and the determination will therefore be more satisfactory. The fat may be determined in the total solid matter by macerating with ether or amyl alcohol and decanting. The fat may also be calculated from the total solids with a fair degree of accuracy by the following formula:

$$F = 1{\cdot}104\ T - 10{\cdot}4,$$

where F = the fat, and T = the total solids.

The ash is determined in the solids not fat by ignition. A high percentage of lime in the ash may indicate the presence of viscogen. About 22 per cent of the ash should be lime, and the ratio of lime to phosphoric acid should be 1 : 1·3 ($CaO : P_2O_5$).

Richmond gives the analysis of thick cream as follows:—

Water	39·37	per cent
Fat	56·09	"
Sugar	2·29	"
Proteids	1·57	"
Ash	0·38	"
	99·70	per cent

The average composition of clotted cream he gives as—

Water	34·26	per cent
Fat	58·16	"
Solids not fat	7·52	"
Ash	0·60	"

[J. Go.]

Cream Cheese. — We may set down cream cheese as a food and a relish—a dietetic luxury rather than an everyday article of food. It is an excellent thing in itself, by virtue of its inherent quality. The only point not in its favour—and that a point of no great practical importance—is its immaturity and lack of ripeness, acquired by age, at the time when it is generally eaten. The Stilton was formerly to all intents and purposes a cream cheese—literally a cream cheese to a degree surpassing much of the cream cheese that is made nowadays, especially in France, the chief exemplar in 'soft cheese'. But there are genuine English cream cheeses on the market; and these command, as they ought to do, remunerative prices

A cream cheese that merits the name is made of cream, pure and simple; it is not a soft cheese made from new milk only, with all its own cream in it and nothing more. There is no milk of cows rich enough in cream of its own to make what we naturally understand the phrase 'cream cheese' to mean,—not even the milk of Jersey, or Guernsey, or Kerry cows. And yet the impossible is being constantly attempted: fresh, new milk is coagulated and put into moulds resting on little mats of straw, or into muslin bags, or into small wooden boxes whose sides and bottoms—if they have any—are perforated, or into anything else that anyone may devise to enable the superfluous water of the milk to drain away from the curd. But this, when made, and when it has attained the customary degree of maturity, is not cream cheese. It is new-milk cheese, if we will, but not cream cheese.

A genuine cream cheese,—which, indeed, must be made from cream only, and not from mere milk as such—if well ripened by the action of lactic acid, is a delicacy of no small account, and as such is widely popular with those who can afford to indulge in it. Not, however, is it an extravagant delicacy, but a wholesome and nutritious article of food, and withal a good thing medicinally.

The making of cream cheese is the simplest of processes in the whole round of dairy products, inasmuch as it is within the capacity of any amateur in dairying. Cream that is slightly acid from the action of the bacillus common alike in the making of butter and of ordinary cheese of whatever kind, really makes itself into cream cheese automatically. The equipments of a cream cheese dairy are few in variety and also in number. Moulds of simple design and construction, home-made if you will, answer as well as more elaborate ones made elsewhere. They must be of odourless wood, or of some other material—round, or square, or oblong, or of any other shape, a couple of inches deep (lined with a loose piece of muslin), perforated on the sides, and without bottoms, standing on

small mats of clean straw. In this way the draining is facilitated, and the cheese makes itself in a few days' time. [J. P. S.]

Creamometer. — The simplest and one of the earliest methods of milk testing is to set a small quantity of milk, warm from the cow, in a graduated glass tube, allowing the cream to rise under the action of gravity, and to observe the volume of the cream layer which forms at the surface. The tube used for this purpose is termed a cream gauge or 'creamometer'. It was found, however, that the percentage of cream rising to the surface under the action of gravity does not necessarily bear a constant relation to the percentage of fat in the milk; that the percentage of cream obtained in this way depends upon the size of the fat globules in the milk, and the conditions under which the milk is placed. While creamometers, therefore, furnish a useful indication of the character of milk, they cannot be relied on to show its composition accurately. See art. on MILK TESTING. [W. ST.]

Cream Raising.—Until after the middle of the 19th century the raising of cream was left in the enjoyment of its own natural tendency. That is to say, milk was put into more or less shallow pans and left at rest for a day or longer, during which time the cream it contained rose slowly to the surface. Not all of the cream, however, rose in that way, or rose at all; for some of the fatty orbs of which cream is mainly composed remained stationary in the milk, whilst others gravitated slowly downwards. Skimmed milk, therefore, was seldom if ever wholly destitute of butter fat, though the residue varied more or less in accordance with conditions that were either natural or artificial, as the case might be; and were very little understood, whatever they may have been.

It had been ascertained that, as butter-fat globules in milk vary considerably in diameter, it was the larger ones that soonest came up to the surface of milk. The buoyancy of these was naturally greater than that of the smaller ones, and it was this that enabled them to gently shoulder their way upwards. The practice of skimming off such cream as had risen in twelve or fifteen hours, and of leaving the milk still at rest for a second period, was general in old days, and it was found that a second skimming of cream was always obtainable. This second crop, however, came to be recognized as of a quality inferior to that of the first, if separately made into butter. From this ascertained fact arose the phrase 'gilt-edged butter', which was given —first of all, it would seem, in the United States of America—to butter made from the first crop of cream.

Later on it was found that cream raising was expedited by a slowly falling temperature of the dairy, as in the case of a lowering temperature of the air in, for instance, the fall of the year, when the nights are commonly colder than the days. This practical observation led to experiments with pans of milk placed in cold water, and developed into what became so popular in the 'seventies and 'eighties of the 19th century; it was known as the 'ice-water system' of cream raising. This system won a quite extraordinary acceptance in several countries of north-western Europe, and to a considerable extent also in some of the dairying States of North America. It might, and probably would, have become equally popular in the British Islands too, but for the difficulty of securing an ample supply of suitable ice in winter for use in summer. Many systems of cream raising with cold water were developed, but these have practically been all superseded and swept away by the advent of a new mechanical magician, known at first as the 'centrifugal cream separator', but now as 'separator' simply and briefly. [J. P. S.]

Cream Separating. — Thirty years ago the separator did not exist, save in the most simple and rudimentary form of glass tubes, containing milk, that were attached to spokes of wheels in a frame; this was caused to rotate at a high speed for a few minutes, at the end of which time the cream was found collected at the inner end of the tubes, whilst the skim milk had withdrawn itself to the outer ends. Centrifugal force had been brought into use by rapid rotation of the wheels, causing the heavier portion of the milk to fly to the outer circumference.

The separator, indeed, is one of the clever inventions of the age in which we live, and its destiny has been to revolutionize the practice of buttermaking throughout all progressive buttermaking countries. This destiny is not as yet fully accomplished, but that it is making rapid progress in that direction is abundantly clear all around.

By the aid of separators, fresh cream is obtained from fresh milk, and such cream is in good form for the 'ripening' which cream should undergo in order to produce the finest samples of butter. It is not too much to say that the separator is now first in the dairy, and that all other methods of cream raising are obsolete or moribund. So great a victory in the dairy world is a very notable thing. See SEPARATOR. [J. P. S.]

Creeper.—This term is properly applied to plants that grow along the ground rather than climb; but it is also used to describe plants of distinctly climbing habit. A good example of a true creeper is the Strawberry, which sends out prostrate stems from the nodes of which adventitious roots are developed. [W. W.]

Cremation. See CARCASSES, DESTRUCTION OF.

Creosote is the term given to a liquid obtained by distilling coal and wood tar. It is of considerable commercial importance, and is extensively used in the industrial arts. The creosote from coal tar is produced in the largest quantities. When coal tar is distilled the fraction which comes over between a temperature of 204° C. and 404° C. forms the creosote. It is sometimes called heavy oil or dead oil, and it is composed of a mixture of liquid and solid hydrocarbons. Its appearance and character differ considerably according to the kind of coal used in its preparation. It may vary from a semi-solid to a thin liquid at the ordinary temperature, depending upon the proportion of liquid to solid hydrocarbons yielded by the coal.

The thin liquid and easily volatile kinds are lighter than water, whilst the more viscid kinds are heavier than water and not so readily volatile. Occasionally, creosote is of a greenish shade in colour, and exhibits a certain amount of fluorescence. It possesses a highly characteristic but unpleasant odour. Wood-tar creosote is obtained from beech wood; when this wood is distilled, oils heavier than water come over. These, after purification, yield a distillate, which comes over at a temperature between 200° C. and 220° C. This distillate represents the wood-tar creosote. It is composed of a mixture of liquid hydrocarbons, somewhat differing, however, in chemical composition from many of the hydrocarbons obtained in the coal-tar creosote. It possesses a characteristic odour.

Creosote is used for the following purposes: preserving of timber, softening of hard wood, as liquid fuel, for lighting, burning for lampblack, as an antiseptic, and as a cattle wash for destroying animal parasites. See also TIMBER, PRESERVATION OF. [R. A. B.]

Crepis is the botanical name for a genus of Composite weeds belonging to the division with milky juice and all the flowers ligulate (Ligulifloræ). The common name is *Hawk's-beard*. These weeds are distinguished from allied plants by the cylindrical and ribbed fruits, which are crowned by a tuft of soft white hairs, not feathers. There is no long stalk or beak for the hairs, as there is in a dandelion.

The important weeds belonging to this genus are: Smooth Hawk's-beard (*Crepis virens*), a yellow-flowered annual in dry pastures. The heads are small. Marsh Hawk's-beard (*Crepis paludosa*), a yellow-flowered perennial in moist pastures. The heads are about 1 in. in diameter. [A. N. M'A.]

Cress, a name applied to a number of plants, mostly of the order Cruciferæ. The Garden Cress (*Lepidium sativum*) is a hardy annual from Persia which has been grown for centuries in this country for salading. The seeds are sown in early spring in boxes in frames, or later in the open ground, and the seedlings are eaten when very young. Seeds of Mustard are sown at the same time under the same conditions, and the young seedlings used along with those of Cress. There are several recognized varieties of Cress, such as broad-leaved, curled or Normandy, and Golden or Australian Cress. Water Cress (*Nasturtium officinale*) is also known as Cress. For particulars of this see under WATER CRESS. [W. W.]

Cress.—Parasitic Fungi.—The forcing methods employed to obtain Cress and Mustard for salad purposes are conducive to the growth of fungi parasitic on these and other Crucifers (see CABBAGE, TURNIP, and RADISH). Damping-off fungi, such as *Pythium debaryanum*, may be particularly destructive among the tender overcrowded seedlings, and they are rapidly killed off by rotting near the surface of the soil. It is therefore necessary to keep a sharp lookout for the first indications. After a box or pan is once attacked, it is probably simplest to burn both soil and plants; much may be done in this way to keep the pest in check. At the same time, improved ventilation is necessary to save the rest of the crop. The use of clean fresh soil is the best safeguard, and it may be found profitable to sterilize the soil by heat or by steam. [W. G. S.]

Crested Dog's-tail (*Cynosurus cristatus*) is a perennial grass found wild all over Britain in pastures, lawns, and parks. It has small narrow leaf-blades, and accordingly takes a place alongside Perennial Rye Grass as a 'bottom' or 'sole' grass. From other 'bottom' grasses the shoots are readily distinguished when pulled out of the ground. The sheaths at the base of a Dog's-tail shoot are quite yellow, as if the yolk of an egg had been spilled over them, whereas the corresponding sheaths of a Perennial Rye Grass shoot are bright-red or pink. The shoots are arranged in tufts sufficiently loose to form a complete sward of grass, if the seed is thickly sown. In fact, Dog's-tail by itself without admixture is sometimes sown to produce a lawn, and indeed it is the rule to incorporate a good deal of this seed in all lawn mixtures. If shoots in a pasture are examined, one usually finds that the Dog's-tail is kept closely cropped by browsing stock. The straw, however, has the peculiarity of becoming hard and wiry at a very early stage of growth, and such wiry growths are left standing as 'windlestraws'. Hence it has been inferred that Dog's-tail is of use only for producing straws suitable for cleaning out the stems of tobacco pipes. This inference is certainly false. A sounder inference would be that Dog's-tail is unsuitable for producing good hay, for the straws are not only wiry, they are also short, not longer than 2 ft.

Crested Dog's-tail (*Cynosurus cristatus*)

The ear at the end of the straw is very characteristic. The figure shows that the axis of this ear is slightly zigzag, simple, and quite bare at one side. On the opposite side of the ear, the spikelets are so densely compacted that no sign of the axis is visible. A spikelike ear with the axis bare on one side and quite hidden on the other belongs to the Dog's-tail Grass alone. The figure also shows comblike bodies with two rows of teethlike scales: these are not ordinary spikelets engaged in the business of seedmaking, but completely barren structures. The barren spikelets play the part of protectors for the fertile seed producers. The former are outer, the latter inner, lying as it were covered up in the bosoms of their protectors. In this position the fertile spikelets gradually mature their seeds,

and gradually break up into pieces which readily detach and shake out. These pieces of spikelets are sold in commerce as Dog's-tail seed. Naturally enough, the seed grower crops his Dog's-tail in an imperfectly matured state, for if he waited longer, the loss from shaking would be considerable. Accordingly, it is for the purchaser of this seed to assure himself, say by a written guarantee from the seller, that the seeds supplied have a certain percentage of germinating power

The 'seed' is composed of a cylindrical stalk, and a two-valved husk enclosing one grain. The valve of the husk away from the stalk is rounded, not V-shaped, very yellow at the base, and towards the point covered with numerous short white bristles. This 'seed' cannot lie on its side because of the round back, and the sharp point has a slight but characteristic bend to one side. The dimensions are usually 3½ mm. long by 1 mm. broad.

A small proportion of Dog's-tail may be incorporated in all mixtures which are intended to last longer than three years, say ½ lb. or 1 lb. per acre. For shorter leys, Dog's-tail is useless, as it makes very little growth during the first years of its life. It must be remembered that this is a self-sowing grass: in a pasture many ears reach maturity, shed their seed, and produce new plants whenever they can find bare soil on which to germinate. [A. N. M'A.]

Cretaceous System. — This geological system is characterized in France and the British Isles by the prevalence of a pure-white limestone (chalk; Latin *creta*) in its upper strata.

	Subdivisions (stages) established by French geologists.	Representatives in England.
Upper Cretaceous Series.	8. Danian.	(Unrepresented.)
	7. Senonian.	Upper Chalk.
	6. Turonian.	Middle Chalk.
	5. Cenomanian.	Lower Chalk. Part of Upper Greensand.
Lower Cretaceous Series.	4. Albian.	Part of Upper Greensand. Gault Clay. Part of Folkestone Beds.
	3. Aptian.	Part of Folkestone Beds. Hythe Beds.
	2. Barrêmian.	Atherfield Clay.
	1. Neocomian.	Wealden Beds.

The term Neocomian has been extended by some authors so as to include the strata from the base of the Wealden to the top of the Folkestone Beds. The beds from the base of the Atherfield Clay to the top of the Folkestone Beds are very generally referred to as the Lower Greensand series, since glauconite occurs freely in them, and colours them green when they are struck with a spade or hammer. Except for the interesting marine beds at Tealby in Lincolnshire, and at Speeton, north-west of Flamborough Head, the opening beds of the English Cretaceous system are of freshwater origin. The Wealden strata are named from the old forest country of the Weald (compare German *Wald*). Owing to the wearing away, since Pliocene times, of a great arch of higher Cretaceous strata,

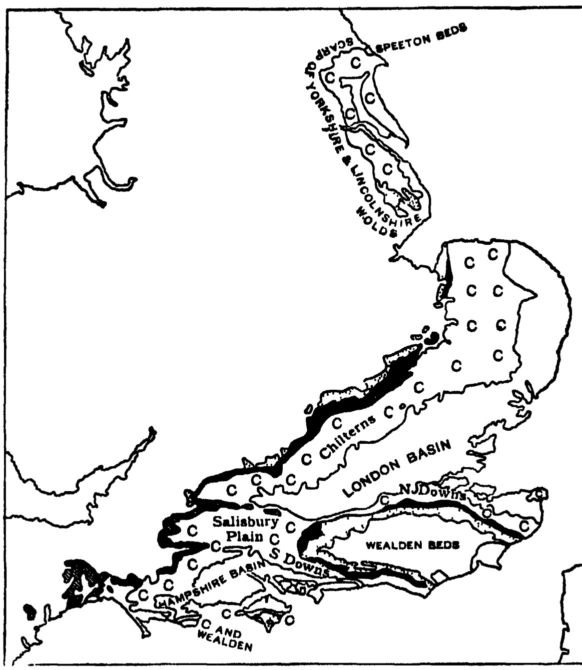


Fig 1.—Sketch Map showing Distribution of Cretaceous Strata in England *Lower Greensand series*, dotted, *Gault clay*, black; *Upper Greensand* (mostly sandy beds of Gault age), shaded with oblique lines where not too thin to be represented; *Chalk* (usually marly at base), marked C

they are now exposed between the scarps of the North and South Downs. The *Hastings Sands* at the base form an area of soft sandstones, with some clays, culminating in Ashdown Forest, an east-and-west ridge often crowned by fir woods. These sands form dry open heaths and commons. The *Weald Clay*, with its damp flats and abundant oak woods, surrounds the area of the Hastings Sand, except on the east, where the great arch, the 'Wealden anticline', is cut across by the Straits of Dover. Some freshwater limestone occurs in the clay deposits here and there. The clay makes good bricks, and the woods formerly provided fuel for the furnaces that smelted the ferruginous sandstones of the Weald. The first beds of the Lower Greensand series are marine clays (see art. Atherfield Clay). The Hythe Beds above are glauconitic sandstones, with some chert, which aids in cementing the mass. The beds thus form a conspicuous escarpment along the north side of the Wealden hollow, protecting the wet Atherfield Clay below. Leith Hill, near Dorking, nearly 1000 ft. above the sea, is a picturesque promontory of the scarp, and from it one can see the hills to the west jutting out one after another, clothed with dense fir woods

on their dip-slopes, which here fall towards the north. The Folkestone Sands on the back of these slopes are less coherent, and are traversed by deep sandy lanes. The amount of uncultivated and unfenced land in Surrey is a continual surprise to dwellers in London; and the woodland paths connecting picturesque old hamlets, built in clearings by the springs, afford some of the most charming scenes of rural England. To the Folkestone Sands, whether we are on the north or the south side of the Weald, succeeds a band of wetter land, with oak-trees and rushes in damp hollows, where the Gault Clay comes to the surface. This clay is largely used for brick-making, and forms a flatter strip along the foot of the bold escarpments of the Chalk. The Upper Greensand is a localized formation, which often produces a small scarp parallel with the foot of the Chalk, owing to its being a calcareous sandstone ('firestone'), and to its being strengthened by chert. In part it is a sandy representative of the Gault, in part a sandy base to the Lower Chalk stage.

The great mantle of Chalk that follows is marly at the base, and is a purer limestone in the upper strata, where layers of nodular flint abound. It represents three whole stages of the Cretaceous system, and is best known to agriculturists as forming the sheep-grazing lands of the South Downs. North and west of London it has been worn back from its former westward extension, and presents a long scarp, parallel with that of the Cotswolds, which runs across Dorsetshire, through Wiltshire, Oxfordshire, and Buckinghamshire (where it forms the Chiltern Hills), and which dies down somewhat through Cambridgeshire and Norfolk. At its foot, representatives of the Lower Greensand, not quite continuous, form sandy areas, as at Woburn, reminding one of those in Surrey. Phosphatic deposits, with fossils derived from lower strata, occur in this Lower Greensand of the midland counties, and on the top of the Gault in Cambridgeshire (see art. PHOSPHORITE).

The Chalk, with its undulating surface of rounded hills, its steep-sided dry valleys, its soil-caps of flint gravels or of clays derived from lost Cainozoic strata, forms a broad plateau-land descending eastward and south-eastward across Norfolk, Suffolk, and Hertfordshire, until

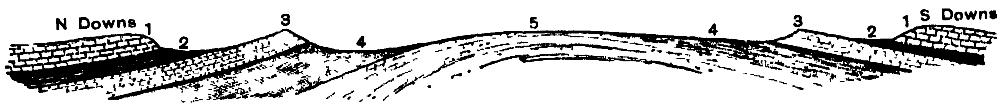


Fig 2—General Section across the Weald, S E. England. Vertical section about ten times the horizontal. 1, Chalk of N. and S. Downs, sometimes with sandy beds ('malm-rock' or Upper Greensand) at its base 2, Flat land of the Gault clay 3, Sands of Lower Greensand series, with Atherfield clay at base. 4, Weald clay, spreading as a lowland from foot of scarp. 5, Hastings sand, sometimes rising as forest land in centre of the arched series of strata

it dips under the clays and sands of the London Basin. In Wiltshire it similarly extends as a hummocky plateau south of the fine scarp of Marlborough Downs, and this grass-grown and exposed surface, far from regular, is known as Salisbury Plain. From the east of this plateau, in the more wooded and varied lands of Hampshire, the Chalk is exposed through Surrey and Kent as the North Downs, and as the South Downs across Sussex as far as Beachy Head. It rises again from under the Cainozoic clays to form the axis of the Isle of Wight. Clumps of beech trees often mark the sites of ancient camps upon its crests, and beech woods spread over parts of the dip-slopes. The great white quarries opened for lime-burning on the scarps are conspicuous many miles away.

The Cretaceous in Scotland is practically limited to a few sandy strata on islets off the western coast. In Ireland, however, the sheets of Cainozoic basalt have preserved Upper Cretaceous sandstones and limestones in the counties of Down, Antrim, and Londonderry, and the 'white limestone', an indurated chalk of about one-tenth the thickness of its English representative, crops out below the scarp of black lavas from Belfast Lough to Limavady and Moneymore. This Irish chalk appears over a very limited area, but is much quarried for lime in a region which would otherwise be very poor in this respect.

[G. A. J. C.]

CRETACEOUS SOILS.—The great differences in the constitution of the rocks of the Cretaceous system are responsible for the wide variety of soils, ranging from light sands to stiff clays, which are found within the area

At the base, the *Hastings Sands* form a sandy loam of a yellowish or brownish colour, and almost sterile because of the presence of an excess of iron. Stiffer soils, of course, occur at the outcrop of the clay beds which alternate with the sands, but these are local variations of very circumscribed extent. As a rule the land is unenclosed, and is covered with furze and heaths and their associations.

The product of the *Weald Clay* of Kent, Surrey, and Sussex is an extremely stiff yellow brick-clay, destitute of lime, and, on account of its impervious character, requiring artificial drainage. The extreme fineness of division of its constituents is the outstanding peculiarity of this soil. The mechanical analysis of the soil of a Wealden wheat-land showed that 37·14 per cent of its constituent particles were below ·01 mm. ($\frac{1}{2500}$ of an inch) in diameter, and that 44·26 per cent of them lay between 2 mm. and ·01 mm. ($\frac{1}{12}$ and $\frac{1}{2500}$ of an inch) in diameter (Journal of the South-eastern Agricultural College of Wye, July, 1906). It contains neither stones nor gravel, and normally but a small percentage of vegetable matter. When worked in the wet condition, the earth becomes so hard on drying that it is very difficult, if not impossible, to reduce it to a suitable state of tilth. Much of the Weald-Clay area is under pasture, to which it is best adapted; but when drained, limed, and skilfully cultivated, good crops of wheat, pulses, roots, and even hops are successfully grown.

The *Atherfield Clay* yields a stiff, wet, brown soil very difficult to cultivate. It possesses in some places an abundance of lime derived from the interbedded limestone strata.

The calcareous sandstones or 'ragstones' which occur in Kent in the *Hythe Beds* produce a soil of a very fertile description, particularly adapted to hop culture. In some places, where the beds are more crumbling and siliceous (locally styled 'hassock'), the soil is light and sandy. This soil is also of fairly good quality, but is much improved in texture and capabilities where it is mixed with the neighbouring Wealden earth. The cherty sandstones of the Hythe series in west Surrey are largely given over to fir woods and heath.

Above the Hythe formation, the *Sandgate Beds* develop, in the few circumscribed areas that they occupy, stiff clay loams, which, when well drained, make good wheat land. The soils on the adjoining *Folkestone Sands*, on the other hand, are of a light, sandy nature, and yellowish to reddish in colour from the ferruginous character of the sandstones from which they are derived. Where they contain a proportion of lime, as in the district between Ashford and Folkestone, they are fertile, but in the absence of that constituent they form commons and heaths (M'Connell, Agricultural Geology, p. 208).

The *Gault* is a blue calcareous clay, producing strong stiff lands, very sticky when wet, and expensive to cultivate. Within the Gault area the soils are very varied, from admixture with material from other formations. In the Vale of the White Horse, in Berkshire, a rich friable loam, containing much lime, is formed from a combination of Gault Clay with the overlying malm and Upper Greensand. Throughout Oxford, Berks, and Bedford the natural soil is modified by foreign material, containing rolled and angular flints, which convert it into a friable loam of considerable fertility. In the district round Arrington, in Cambridgeshire, and extending to near Huntingdon, the soil is of a grey or yellow colour resting on a yellow subsoil. This soil represents the poorest land on the Gault formation (Morton, Nature and Property of Soils, p. 47). Since much of the Gault area occupies the lowest ground of the districts in which it occurs, it is badly drained, and otherwise excellent wheat lands are occupied by pastures of an inferior kind.

The soils of the *Upper Greensand* consist of sands or sandy loams; the deeper subsoils are of a greenish colour from the presence of glauconite. They are rich in lime and phosphoric acid, and are suitable for all the ordinary farm crops. Turnips, potatoes, barley, and hops do particularly well on them. A considerable amount of the land on this formation is under tillage.

The material of the lowest stage of the *Chalk*, known locally in Hampshire and the London Basin as 'malm', is a calcareous deposit (Chalk Marl), which, like the Upper Greensand, sometimes contains glauconite (Chloritic Marl). It possesses the peculiarity of breaking up into a fine powder on exposure to the air. Because of the high proportion of lime it contains—often from 40 to 50 per cent—it is much used as an amendment for the clays of the neighbouring formations, and even for the chalk land from which the lime has been leached out. The soil is a grey calcareous loam, attaining a very high degree of fertility where it mixes with the Upper Greensand.

The remaining stages of the Chalk series consist of land almost entirely devoted to sheep-farming. The soil is typically a loam, formed, like the soils of the Carboniferous Limestone, from the impurities in the original chalk rock. In the higher grounds it is very dry and friable, supporting a short sweet pasture much favoured by sheep. The hills or downs have, in fact, been used as sheepwalks from time immemorial, and the South Downs of Sussex have given their name to a celebrated breed of sheep originated among them. The Turonian or Middle Chalk soils are without flints, but sometimes the Turonian hills are covered to a considerable depth with flint gravel, representing the remnant of the vanished Upper Chalk. At Buckland Newton, on the Dorset Downs, the deposit is 20 ft. in thickness (M'Connell, Agricultural Geology, p. 212). These flint soils have all the characteristics of ordinary gravels.

The Upper Chalk or Senonian stage, which includes most of the South Downs of Sussex and the Wolds of Yorkshire, furnishes thin soils containing a large proportion of flints, and not sufficiently retentive of water. A good deal of arable land is to be found in the lower grounds of this formation, affording excellent soils for the production of barley, turnips, and wheat, as may be seen towards the west side of Salisbury Plain. The chief difficulty of farming on the Chalk Downs is the absence of permanent water; ponds are apt to run dry in summer, and the level of water in wells shows considerable variations. [T. H.]

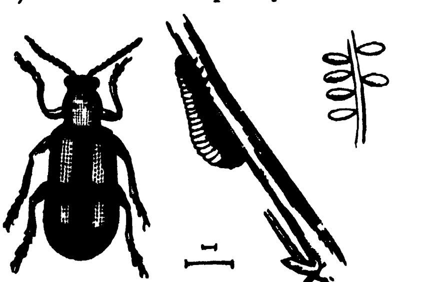
Crevecœur Fowl.—To French breeders we owe several valuable breeds of poultry, in which not only are those special characters defined the combination of which give individuality and form a distinct type, but at the same time the egg-laying or meat properties have been kept constantly in view. Local conditions have also been utilized to the full. Thus it is we find many of the Departments or districts of France have their own breeds of fowls (see BRESSE FOWL, DU MANS FOWL, FAVEROLLES FOWL, HOUDAN FOWL, LA FLÈCHE FOWL), evolved there, and consequently suited to their environment. Of these the Crevecœur is a notable example,—a native of Normandy, but owing some of its characters to breeds from other countries, as it differs greatly from the majority of French races. Whilst it cannot be said to hold the premier position either for egg production or table qualities, it is excellent in both directions.

The most striking feature of the Crevecœur is the large round crest and the horned comb, showing that the Polish or Dutch crested fowls have shared in its origin. Whilst this is distinctive, at the same time the results are not advantageous, as the presence of a crest in a moist climate means susceptibility to cold. Even

in France the breed is regarded as delicate, and there the conditions are more favourable. This feature explains why the Crevecœur has never become popular in Britain, in spite of its excellent qualities. The plumage is entirely black, and the body is broad, deep, and long, with the breast carried well forward. The legs and feet are light in bone, and dark slate or black in colour; they are short. There are also blue-and-white Crevecœurs, but very few of these are found. The hens are good layers of large, white-shelled eggs, and they become broody very seldom. The chickens are quick in growth, are very quiet in disposition, and fatten well, forming a large proportion of flesh on the breast, which is fine in texture and beautifully white. Hence they make very good table fowls, though the skin does not fill out quite as well as the Bresse and La Flèche, in which respect they follow the Dorking. But for the delicacy of constitution referred to, the Crevecœur would be much more useful as a utility fowl. [E. B.]

Crib-biting.—Commonly regarded as a vice, but in reality a nervous affection, crib-biting must be deemed an unsoundness. Much study has been given to the subject, with but little result. It appears to be born of idleness or want of occupation, and may amount to nothing more than biting the manger, or develop into a habit of sucking wind, with disastrous effects upon the system. Colic, tympany, chronic indigestion, wasting, and loss of efficiency are the results of the habit. A tight strap round the throat is the most successful remedy hitherto employed. [H. L.]

Crioceris asparagi (the Asparagus Beetle).—This beetle frequently does harm to



Asparagus Beetle (*Crioceris asparagi*), larva, and eggs; all magnified. The lines show natural length of egg and of beetle.

asparagus both in its larval and adult stages by eating the stems and fronds, quite stripping the latter of the epidermis and so causing loss of seed; the larvæ also eat the shoots and spoil them for market. The beetle is ⅕ to ¼ in. long, slender and graceful, shiny black with a blue tinge, thorax red, wing cases with outer margins pale-yellow, inner black, and a transverse bar of black across them. Each elytron has three lemon-yellow spots, which with the black bar and margins form the figure of a cross. The beetles hibernate and lay eggs from June onwards, which are oval, dusky-greenish-brown, glued by their ends in rows of three to five on the shoots and fronds; they are 1/16 in. long and covered with a gummy coat. The larvæ hatch in five to seven days. They are nearly ½ in. long when full fed, of a dirty-greenish-grey to slate colour, with wrinkled skin, with six true legs and fleshy footlike tubercles on the segments, and a caudal proleg. The larvæ live from ten to thirteen days, and then pupate in the soil in a cocoon of parchment-like material covered outside with grains of earth; this stage lasts fourteen to twenty days.

Treatment consists of dusting the heads with lime; leaving a few heads uncut for them to oviposit on, and burning these; spraying the fronds with arsenate of lead. Ducks turned on to the beds have also been found to do much good. [F. V. T.]

Crithmum, or more fully *Crithmum maritimum*, is the botanical name for the Sea Samphire. This is a succulent umbelliferous plant, easily distinguished from all others of its order by the curious leaves. The leaf has a wax-covered skin, and its blade is divided into three parts; each part is again divided into three segments, which are very narrow, thick, and succulent, about 1 in. long. This succulent plant is perennial, scarcely a foot high, and in its wild state confines itself to rocky cliffs by the sea. It is used as a pickle, an ingredient in salads, and as a potherb. [A. N. M'A.]

Crock Ewe, a term used somewhat loosely to denote any old ewe past the stage of breeding. Such ewes are generally fattened off on the turnips and sent to the butcher.

Crockles, or **Cripples,** a rheumatoid affection of cattle, chiefly observed upon sour, undrained, marshy, and mossy land. Arching of the back and a stilted gait, a hidebound appearance, loss of flesh, and of milk in the case of cows, and a morbid appetite which leads to the devouring of bones and foreign bodies of various kinds, are the characteristic symptoms. Young bulls are liable to become crippled with this affection when kept on stone floors and insufficiently exercised. *Treatment* consists in change of pasture, better drainage, or the substitution of raised wooden floors for bulls; the administration of turpentine and oil two or three times a week, or of salicylate of sodium, and gentle saline purgatives, with greater freedom and exercise. Soils with a reputation for this disease should be dressed twice a year with lime and salt. [H. L.]

Crocks, the term used by gardeners for the pieces of broken flower-pots, also called potsherds. The use of crocks as drainage to the soil in flower-pots is general, probably because they are always available. They serve to keep the soil aerated, and as they consist of burnt clay they contain nothing that would disagree with the roots of any plant. Being porous they hold moisture, and they are sufficiently soft to be easily removed without injury to the roots, which often form a network about them. [W. W.]

Crocus, a large genus of bulbous plants of the Iris family. The species are distributed over the temperate regions of the Old World, one of them, *C. vernus*, being a native of the

British Islands. From it and *C. aureus*, a native of south-eastern Europe, the best of the Dutch crocuses have been derived, whilst the showiest of the autumn-flowering kinds are forms of *C. pulchellus*, a native of Asia Minor. The cultivation of crocuses is simple; they thrive in any ordinary soil, and are not difficult to establish as permanent plants in the wild garden. Mice are their worst enemies, greedily eating the corms in winter, when food is scarce. The showiest sorts are planted in beds and borders in late autumn, to flower the following spring, and they are so cheap that it is usual to dig them up after they have flowered, replacing them in autumn with a fresh supply. In addition to the Dutch sorts, the species proper deserve to be grown, especially along with alpine plants in rockeries. The best of them are *C. aureus*, *C. biflorus*, *C. chrysanthus*, *C. Imperati*, *C. medius*, *C. pulchellus*, *C. reticulatus*, *C. speciosus*, *C. susianus*, *C. versicolor*, and *C. sativus*. The last named yields the saffron of commerce, and was formerly largely grown at Saffron Walden; it is one of the oldest cultivated plants, being mentioned in the Old Testament. The corms produce offsets freely, and if they are dug up soon after the leaves die down and the offsets replanted separately, they soon become plentiful. In Holland the cultivation of the Crocus is now an important industry, and there is no reason why it should not be developed in this country, especially in districts where the soil is light and sandy. [W. W.]

Crœsus septentrionalis (the Nut Sawfly).—The larvæ of this sawfly feed upon cob and filbert leaves, and also on those of the wild hazel nuts, osier, aspen, birch, poplars, and mountain ash. The sawfly appears in May and June. It is about ½ in. long; shiny-black, with the mid segments of the abdomen brickdust red; it is readily told by the flattened hind metatarsus and apex of tibiæ, the flattened parts dark, the base of legs white. The ova are laid in slits on the leafage. Larvæ are found in July and August, and on to end of September. When mature they are greenish-blue, the second and anal segments bright-yellow, with dark spots at the sides. They feed in groups of three to ten, usually in a row, on or near the edge of the leaves, holding on by their true legs, the bodies being curled in all manner of positions. When mature they form a brown parchment-like cocoon in the soil. There are two broods during the year. The larvæ of the second brood all remain as such during the winter in their cocoons in the soil, and pupate in spring.

Treatment consists of spraying with hellebore wash or arsenate of lead, and removal of surface soil during winter. Hellebore wash is made by mixing 2½ lb. of fresh-ground hellebore with 10 gallons of water. [F. V. T.]

Crofter Holding Act. See next article.

Crofter Legislation.—The first Act, 'The Crofters' Holdings Act, 1886', was passed upon the report of an enquiry conducted by the Napier Commission, after the agrarian disturbances in Skye and Lewis in 1883 and 1884. The Napier Commission said in their report: 'The Crofter of the present time has through past evictions been confined within narrow limits, sometimes on inferior and exhausted soil. He is subject to arbitrary augmentations of money rent, he is without security of tenure, and has only recently received the concession of compensation for improvements.'

The Commission found that the greatest general grievance of the crofters was the restricted area of their holdings. Rackrenting might have been popularly regarded as the greatest grievance, but rackrenting was made possible by the constant demand for a restricted supply of land. The case of the crofters indeed was but a particular instance of the general rule, by which the small holder had given place to the large farmer, when agriculture for profit was substituted for agriculture for subsistence. The crofting small holder had had to make way for the sheep-farmer. The Commission accordingly (regarding the crofting 'township' as the unit of the crofters' rural economy, and a unit worthy of preservation) recommended that the land still under crofts should be saved from further diminution, that the areas of congested townships should be enlarged by the assignment of land for pasture, and that fresh townships should be formed on available land. They then made recommendations for the individual crofter within the township, distinguishing there between the 'crofters' and 'cottars'.

The Government ultimately followed a plan which was simpler, though perhaps it hardly touched the whole problem so thoroughly as the Napier Commission scheme would have done. They dealt primarily with the individual crofter and not with the township, and conferred on him security of tenure, subject to the observance of certain statutory conditions, with the right to have a fair rent fixed by the tribunal (called the Crofters Commission) set up under the Act. So far the Irish Land Act, 1881, was followed, but in lieu of 'free sale' the crofters received (1) the right to bequeath his holding to certain members of his own family, (2) a wider system of compensation for improvements than was given under the Agricultural Holdings Act, 1883, with the right to have such compensation fixed by the Crofters Commission, and not by arbitration under the Agricultural Holdings Act, 1883. The crofter could renounce his tenancy upon one year's notice.

The Commission were also authorized to assign land by a compulsory order, in enlargement of existing holdings, upon the application of at least five crofters—this stipulation being made in order to ensure that the procedure should only be used for a crofting township. The Act applied to 'crofting parishes' in the counties of Argyll, Caithness, Inverness, Orkney, Ross and Cromarty, Shetland, and Sutherland, the mark of a crofting parish being the existence of common grazings within eighty years of the passing of the Act.

The Act has only been amended by two small Acts, passed in 1888 and 1891, providing respectively for the delegation of powers by the Crofters Commission to certain of its members, and the establishment of committees to manage the common grazings of the crofter townships.

The Crofters' Holdings Act, 1886, had also contained a provision, apart from its agrarian sections, for loans to crofter fishermen; the system of making loans to enable fishermen, as individuals or sharers in a joint venture, to buy their boats was not very successful, and was abandoned in a few years. With a view, however, to giving facilities for the successful prosecution of the fisheries, and generally for making the crofting districts more accessible to the rest of the country, Parliament provided a vote for marine works, *i.e.* piers, boatslips, &c., in the crofting counties. In 1891 the Government got an Act passed through Parliament to substitute for the ordinary expensive process, by which provisional orders are obtained under the General Piers and Harbours Act, a cheap and simple procedure by which piers, built in the crofting counties under the Highland Works vote, could be vested in the County Councils, who thereby became responsible for their maintenance as 'undertakers', and could levy a rate for that purpose. Under this Act, and by the help of the Works vote and its successor, the Congested Districts vote, many marine works have been built in the Western Highlands and Islands; some have been of little use, but others have helped the crofter population.

The Crofters' Holdings Act, 1886, fell short of the recommendations of the Napier Commission in one important particular, in that it contained no provisions for making fresh holdings. Accordingly in December, 1892, the Government appointed a Royal Commission 'to enquire whether any, and if any, what land in the counties of Argyll, Inverness, Ross and Cromarty, Sutherland, Caithness, and Orkney and Shetland now occupied for the purposes of deer forest, grouse moor, or other sporting purposes, or for grazing, not in the occupation of crofters or other small tenants, is capable of being cultivated to profit or otherwise advantageously occupied by crofters or other small tenants'.

This Commission reported in 1895 that they had scheduled 1,782,785 ac. of land in the crofting counties as suitable (1) either for new (crofters') holdings, or (2) extension of existing holdings, or (3) formation of moderately sized farms. In the course of their report they put on record their observations of the effect of the Crofters Act, 1886.

The passage is as follows:—

'Before leaving this part of our subject-matter we deem it right to place on record the result of our observations as to the effect of the Crofters' Holdings (Scotland) Act, 1886 (49 & 50 Vic. c. 29). Our inspections of land throughout the counties mentioned brought us into immediate proximity with many crofting townships, as well as with the individual holdings of many crofters, and accordingly we derived materials for judgment from a very large portion of the crofting area. Our opinion is that, speaking generally, the Act has had a beneficial effect, and particularly in the following directions. In the first place, the fixing of a Fair Rent has to a large extent removed from the minds of crofters the sense of hardship arising from the belief that they were made to pay rent on their own improvements, or otherwise made to pay at an excessive rate for soil of a poor quality. In the second place, the combination of a Fair Rent with statutory security of tenure has not only taken away or allayed causes of discontent, but has imparted a new spirit to crofters and imbued them with fresh energy. The abiding sense produced that the permanent improvements which a crofter makes upon his holding will, if he complies with certain reasonable statutory conditions, accrue either to himself or to his family successor, will not be taxable by the landlord in the form of increased rent, and, moreover, will have a money value under a claim for Compensation on Renunciation of Tenancy or Removal from his holding, has led to vigorous efforts towards improvement by crofters in many quarters. For instance, we found that more attention is being paid to cultivation, to rotation of crops, to reclamation of outruns, to fencing, and to the formation or repair of township roads; but most conspicuous of all the effects perceptible, is that upon buildings, including both dwelling-houses and steadings. In a considerable number of localities we found new and improved houses and steadings, erected by the crofters themselves since the passing of the Act.

'In the third place, while the Enlargement sections of the Act have not proved so effectively operative as was intended or anticipated, we did not fail to observe, in the various cases of enlargement of holdings which came under our eye, that the enlargements granted had been, so far as they went, of great benefit to the holdings enlarged.

'And in the fourth place, the percentage of arrears cancelled has terminated liabilities which could never have been met'

No legislation followed the report of the Deer Forests Commission; but in 1897 the Congested Districts (Scotland) Act was passed. £35,000 per annum was made available for the improvement of the Congested Districts in the Highlands and Islands of Scotland; to administer this sum a Board of Seven Commissioners was appointed, four being *ex officio* members, the other three being nominated by the Secretary for Scotland, who is chairman of the Board and responsible to Parliament for their actings. A 'congested district' was declared to mean 'any crofting parish or crofting parishes, or any area in a crofting parish or crofting parishes, defined by the Commissioners under this Act, which they shall, having regard to the population and valuation thereof, determine to b a congested district'.

The various purposes to which the Congested Districts Board may apply their funds are as follows:—

'(*a*) Aiding and developing agriculture, dairy farming, and the breeding of live stock and poultry in congested districts: and

'(*b*) providing suitable seed potatoes and seed oats and implements and dairy utensils and machinery or appliances for the making of butter or cheese for crofters and cottars in congested districts: and

'(*c*) providing, subject to the provisions hereinafter contained, land for subdivision among or for enlargement of the holdings of crofters and cottars in congested districts for the purposes of cultivation or grazing, in such manner and upon such conditions and after such adaptations as shall be determined by the Commissioners: and

'(*d*) aiding migration of crofters and cottars from congested districts to other districts in Scotland, and settling any migrants under favourable circumstances in the places to which they first migrate: and

'(*e*) aiding and developing fishing (including industries connected with and subservient to fishing) and the erection and formation of fishermen's dwellings and holdings in congested districts: and

'(*f*) aiding the providing or improving of lighthouses, piers or boatslips, public roads and bridges, and footpaths and foot-bridges, and meal-mills, in congested districts; and providing guarantees for telegraph extensions, or such other postal facilities (including money order and savings bank business) as may be within the power of the Postmaster General to grant under guarantee: and

'(*g*) aiding and developing spinning, weaving, and other home industries in congested districts; and

'(*h*) subject to the consent of the Treasury, aiding the providing or improving of harbours.'

The most important part of the Board's work has been the provision of land for 'subdivision among or for enlargement of the holdings of crofters and cottars in congested districts'.

They have proceeded in two ways: (1) either by the purchase of estates, which they have resold partly to existing crofter tenants, where there have been such, with additions to their holdings, and partly to settlers upon new holdings formed out of the estates; or (2) by helping a friendly landlord to divide farms into small holdings held by crofters and fishermen under the crofting tenure.

In both cases the Board have adapted the land provided, where necessary, by dividing and fencing it, and have made loans to settlers upon new holdings to enable them to build their houses.

In selling to crofter tenants their holdings, the Board offer them at a price equal to twenty times the fair rent fixed by the Crofters Commission, payable in fifty annual instalments, with interest at 2¾ per cent.

The Board have thus disposed of their estates at (1) Strathnaver, (2) Glendale, Skye, and (3) in Barra, by re-sale to 'occupying owners'; they have helped proprietors to form crofter tenancies in North Uist, Harris, Lewis, Skye, Glenelg, Dunbeath, and South Uist. The Board have also sought to improve the crofters' stock by sending round stallions, bulls, and rams, supplying eggs and hens, seed for oats and potatoes; they have made grants in aid of piers at many places, and of roads, bridges, and paths, helped the upkeep of minor lights and the opening of telegraph stations. [J. SI.]

Crops and Cropping.—Crop means the produce or harvest of land under cultivation. Agricultural crops are roughly divided into four classes:—Corn crops: wheat, barley, rye, oats, maize. Green crops: turnips, potatoes, mangels, kohlrabi, rape, &c. Leguminous crops: beans, peas, and vetches. Grass crops, either grown for hay or pastured, include grasses, clovers, and some miscellaneous plants. We also speak of 'forage crops', crops which supply winter feed to farm stock; 'catch crops', quick-growing crops planted after the removal of a grain or a root crop; and a 'crop of lambs', *i.e.* an annual harvest of lambs.

Cropping is the system under which crops are grown, and varies with the district, soil, and climate. Sometimes the rotation to be adopted is stipulated in the lease. See LEASE. [R. H. L.]

Crops, Difference between Agricultural and Woodland. — While the economic principles underlying agriculture and sylviculture are essentially the same, and are applied with the common object of obtaining continuously the largest and most profitable crops in the shortest space of time and under due protection of the capital in land, stock, and labour required for their production, yet there are not more striking differences between field and woodland crops themselves, than exist between farming and forestry as distinct branches of the cultivation of the soil. Agriculture is the oldest of all arts in the history of nations, while forestry is a far more modern art. But now, in many countries where extensive clearances of the primeval woodlands have been made for cultivation, the preservation of the still existing woodlands or the formation of new ones is often a matter upon which successful agriculture greatly depends, with regard to regulating soil-moisture, preventing floods, providing shelter, &c. As to the crops themselves, field crops mature in the course of one year, whereas timber crops usually take from about 40 or 50 up to 100 or 150 years and sometimes more to become mature and marketable; and even young plantations do not begin to yield saleable returns in the shape of thinnings until some years after their formation. Hence, although the amount of capital invested per acre in forming and supervising farm crops is considerably larger than that needed for woodland crops, yet in the latter it is locked up for a far longer time, and in a manner that does not admit of its being meanwhile recovered and reinvested in some other way, except at a very serious loss of capital. Another obvious result of the long period required for growth is that year after year woodland crops are fifty or one-hundred-fold more exposed than field crops to the annually recurring danger of damage arising from both organic and inorganic causes, such as noxious insects and fungous diseases, atmospheric disturbances, the ravages of game, and the wilful or negligent acts of man. Insects and fungous diseases threaten and sometimes almost totally destroy both kinds of crops, and even seventy or eighty-year-old woodland crops have occasionally to be prematurely felled on

this account. Game of different kinds can greatly injure both, and no damage to field crops could well be more complete than the entire destruction of plantations sometimes caused by rabbits. From damage by floods, woods are practically exempt; but while field crops are comparatively exempt from serious damage by gales, these often throw down large blocks of woodland *en masse*, thereby causing heavy loss of capital in immature windfall trees, besides glutting any small local market, and providing breeding-places for noxious beetles, which soon proceed to attack adjoining woods. But, on the whole, experience shows that over long periods of years and extensive areas the total danger from these causes is not greater in forestry than in agriculture. Another difference is that in woodlands the same kind of crop, once properly established, can be grown *in perpetuo*, as the trees do not exhaust the soil in the manner which necessitates a rotation in field crops. Thus, while agricultural land requires to be manured to retain its fertility, woodland crops improve and enrich the soil considerably through the heavy annual fall of foliage, which becomes converted into humus and adds to the productivity of the land so long as the tree-crops can be maintained in close canopy overhead, so as to protect the soil against the drying and exhausting effects of sun and wind, and of weeds that spring up under a broken canopy. But woods cannot be let like farms, nor can loans of money be so easily obtained on them, while it is also more difficult to estimate beforehand the average annual returns from woodlands, even although the agricultural harvests often vary to a more considerable extent than the annual returns actually obtainable from well-managed timber crops. But taking all these considerations into account, and considering that the rental value of farms depends on the demand for them, and that the upward tendency of woodland produce is due to the decreasing supplies of and growing demand for wood throughout the world, practical experience shows that land of good quality yields a better income from agriculture, while poor land is more profitable under timber crops. [J. N.]

Crossbreeding, pairing animals of distinct breeds, *e.g.* Shorthorn cows and Angus bulls, Shorthorn bulls and Dexter cows, Cotswold rams and Hampshire ewes. A 'crossbred' is the result, or rather *a* result, of pairing two members of distinct breeds of the same race, but it must be recognized that it is impossible to draw hard-and-fast lines between pairing different breeds, different races, different varieties, and different species. Crossbreeding (or exogamy) stands opposed to inbreeding (or endogamy), the pairing of near relatives, but the pairing of distant relatives may not be far removed from the pairing of the members of two closely related breeds, or from the pairing of the members of two different families within the same breed. It is important to realize that all the various possibilities and results of breeding are terms in a gradual series. The results of a particular crossbreeding cannot be predicted except on a basis of experience, but in many cases the same kind of crossing is followed by the same kind of result. There are several well-known results of crossing: (1) The progeny may be an intermediate blend of the parental characters; (2) the progeny may show a particulate juxtaposition (without blending) of the parental characters; (3) the progeny may resemble an ancestral form ('reverting'); (4) the progeny may be quite different from either parent, with a character of their own (a new variation); and (5) the progeny may exhibit the (dominant) characters of one parent, the (recessive) characters of the other parent remaining latent (the first step in Mendelian inheritance). Crossbreeding may be resorted to with various expectations—to remedy some defect in the breed, such as loss of vigour or size after close inbreeding; to secure some good quality possessed by one of the breeds; to prompt variation and thus lead possibly to the formation of a new breed. When a particular kind of progeny is wanted for its own sake, *e.g.* for qualities of flesh, and not for breeding from, a given result can often be attained by a crossbreeding; but to attain permanent hereditary results is a more difficult matter, and the good qualities of a well-established pure breed should never be carelessly tampered with. See next article, also BREEDING, CONSANGUINITY, HEREDITY, HYBRIDS, MENDELISM, &c. [J. A. T.]

Cross Breeds. — Many of the modern races of domesticated animals seem to have originated as crosses between more or less distinct strains. The Southdown sheep, for example, has been used to improve the native breed of Hampshire and other counties, and the selected progeny have acquired, as a breed, features which differentiate them quite clearly from their ancestors. Many other instances might be quoted from stud books, herd books, and flock books, but in modern farming practice few attempts are made to originate new breeds by crossing. The experiments of Biffen, Wood, and others, following the rediscovery of Mendel's Law, encourage the belief that such attempts will shortly be made, but, at present, knowledge is fragmentary, and prophecy more than usually unprofitable. Experience has shown that the progeny of two distinct breeds is in many cases more suitable for certain purposes than either of the parents, and it is with those crosses we have to deal.

HORSES.—Of the British breeds of horses the most prepotent is the Thoroughbred or 'blood' horse, and for crossing purposes the Thoroughbred is most frequently the sire. The following are some of the commoner crosses:—

Thoroughbred × *Cleveland Bay*, for heavy-weight hunters. The offspring of this mating is expected to combine the weight and power of the Cleveland with the courage and speed of the Thoroughbred. The cross is not so fast as the sire or so strong as the dam, but for carrying a heavy man across country is superior to both.

Thoroughbred × *Suffolk Punch*, for carriage horses and powerful hacks and hunters.

Thoroughbred × *Clydesdale* or *Shire*, for

heavy carriage horses or van horses. The first cross or offspring of a Thoroughbred and one of the draught breeds is often called a 'half-bred' horse, and is not always in appearance and character a blend of the parents. If the colt or filly resembles the sire, a saddle horse or hunter may be made; if the draught dam, then a heavy van horse or slow harness horse will be obtained. The Thoroughbred mated with half-bred mares and Irish country mares often produces the best saddle and hunting horses. Small Thoroughbreds put to the pony breeds, such as the Welsh Exmoor and Dartmoor mares, produce polo ponies and ladies' hacks.

CATTLE.—Several well-known types of cross-bred cattle are regularly bred for commercial purposes.

Shorthorn × *Galloway*, to give 'blue-greys'. This cross combines the well-flavoured beef of the Galloway with the fattening propensity and early maturing tendency of the Shorthorn. The cross is made either way, but the rule is to use a white or light roan Shorthorn bull. The calves are nearly always blue-grey or blue-roan and polled.

Shorthorn × *Aberdeen-Angus*, to give polled black calves. This is a favourite cross with feeders of stalled cattle, and combines the smooth outline, fine flesh, and popular colour of the Aberdeen-Angus with the massive frame and quick-fattening powers of the Shorthorn. This cross is also made either way, and opinions differ as to which should be the sire; on the whole the Shorthorn is preferred. The blue-greys of Galloway, and the blacks, and less frequent blue-greys of Aberdeen-Angus origin, are regarded as the most superior beef cattle, and for many years they have commanded the highest prices from graziers and butchers.

Shorthorn × *Ayrshire*, to give calves of greater size and aptitude to fatten than pure Ayrshires. This cross is frequently made in dairying districts.

Aberdeen-Angus × *Ayrshire*, to give polled calves suitable for fattening either as veal calves or for grazing and stall feeding. Those last two crosses, although superior to the Ayrshire, are slow growers, and generally require three years to finish.

Red Poll × *Shorthorn*.—This is not a very common cross, but is said to be highly satisfactory. The calves are generally red and polled.

All British beef breeds have probably been crossed with the Shorthorn and with each other, but the above are well-recognized crosses, frequently made with definite object.

Cross cattle are never bred together, for reasons explained in other articles, and, unlike the half-bred mare, the half-bred cow is seldom consistently mated with a pure-bred sire.

SHEEP. — Cross-bred sheep are much more numerous than cross-bred cattle, for the following reasons: (1) There are many more distinct breeds. (2) As all British sheep are wintered out, climatic and other conditions encourage attempts to suit the sheep to the locality. (3) Ewes are relatively less expensive than cows, and can be purchased in large and uniform lots.

Speaking generally, the favourite crosses are Whiteface × Blackface, Short Wool × Long Wool, Lowland × Hill. In point of number the crosses are first of which the Border Leicester and Wensleydale are the sires and the Blackface or Cheviot the dams.

Border Leicester × *Blackface*, to give the 'cross' in Scotland or 'mule' of the north of England. The cross or mule combines the size and mutton production of the sire with the quality and hardiness of the dam. The ewes are generally three-crop or four-shear, and are either lambed in the low-ground arable land, or in a sheltered situation of the moorland or hill farm. Cross lambs are of exceptional merit either for early sale as fat lambs or for finishing during the winter on turnips. Cross ewes are popular for mating with Border Leicester rams to produce lambs for the early fat market.

Wensleydale × *Blackface*.—The Wensleydale is preferred in some parts of the south of Scotland. The progeny are superior tegging sheep.

Border Leicester × *Cheviot*, to give the 'half-bred'. Cheviot ewes which have borne three crops of lambs are utilized in the same way as the Blackface ewes of the same age, but the Cheviot is often bred to the Border Leicester from the first.

'Half-bred' lambs are much in favour for tegging, and half-bred ewes are kept in large numbers to mate with Border Leicester rams to produce 'three-quarter-bred' lambs. The half-bred ewe during the last twenty years has also been used with Shropshire, Oxford, and Suffolk Down rams with the very best results. Oxford cross lambs from half-bred ewes have topped the south of Scotland store markets for several years.

The Half-bred Breed.—Half-bred ewes have been mated with half-bred rams and a strain of half-bred sheep has originated. The name is unfortunate, but the fact remains that sheep with qualities superior for some purpose to the cross, and yet originating as a cross, have become practically a pure breed.

Down Crosses. — The various Down breeds are seldom crossed, but are universally used upon whitefaced Scotch sheep, and often upon Welsh, Kerryhill, and Clun Forest ewes. The following are common and successful crosses: Shropshire or Suffolk ram × Border Leicester, Half-bred, or Cross ewes for early fat lamb; Oxford × Half-bred for tegging sheep; Shropshire × Clun Forest ewes for early lamb; Shropshire × Dorset Horn for early lamb. The following crosses have not proved very successful: Southdown, Shropshire, Oxford or Hampshire Down × Blackface or Cheviot; Blackface × Cheviot.

SWINE.—Cross-bred swine are so little superior to the pure breeds that consistent crossing is seldom adopted on a large scale. Large White Yorkshires are crossed with Middle White Yorkshires to obtain greater size and more lean meat than the latter naturally possess. Berkshires and Yorkshires and Tamworths and Yorkshires are mated for the same reason and to gain earlier maturity. [R. B. G.]

Cross Ploughing.—Cross ploughing, or the reploughing of land approximately at right angles to the direction of the furrows of the previous ploughing, is effective, and frequently more desirable than the mere turning of the soil in the line of the previous ploughing. It facilitates the breaking up of the land and renders subsequent cultivation more easy, besides aerating portions of the furrow which would not be exposed by ordinary ploughing. Repeated treading of the subsoil up the same furrow track is also avoided; also where unevenness in the previous ploughing, whereby the land was not thoroughly ploughed, left some portions of the soil unturned, cross ploughing allows of more thorough work than would probably be effected were the ploughing done in the ordinary way. Where land is very foul, cross ploughing is often objected to because Couch is necessarily cut into shorter lengths, and therefore may be more troublesome to pull out with harrows and cultivators; but where land is stiff the Couch gets broken by the cultivator tines, and too much stress ought not to be laid on this point. Cross ploughing is most effective when the land lies flat; and least so where it lies in narrow high ridges, as in this case the plough cannot be conveniently balanced to maintain a uniform depth as it passes over ridge and furrow. On the whole, where it can be conveniently done effectively, the results are better than when the furrows are turned back in the ordinary way. [W. J. M.]

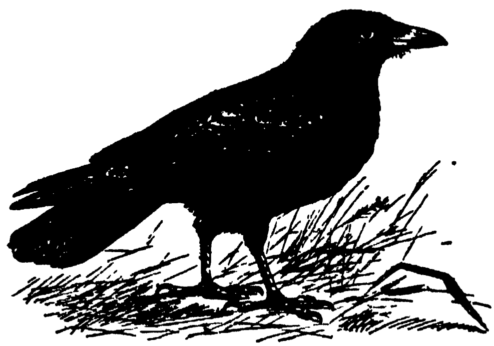
Crowbar, Foldbar, Pole Pitcher, Pitching Bar.—The crowbar is a stout iron bar, generally from 3 ft. 6 in. to 5 ft. long, sometimes with a claw at one end, but with one end pointed It serves a number of purposes, as when used as a lever bar or for making stake holes. In sheepfolding the pointed end makes holes to receive the fold stake to support hurdles; in hop growing the poles for carrying hops are let in by means of the pitcher; in hedge making, holes for the stakes are made by it; in quarry work, both the claw and pointed ends are useful for breaking out stone. As a lever it is useful in many ways on the farm. [W. J. M.]

Crowberry, or **Crakeberry** (*Empetrum nigrum*), is a low, trailing, evergreen, heathlike shrub flowering in early spring. It is common on mountain heaths and in bogs. There are two kinds of plants: the one is male, bearing staminate flowers only; the other is female, and bears the fruit, which is a black globule about the size of a pea. The fruit is not a berry but a drupe; unlike the drupe of a cherry, this contains several 'stones' instead of one. On the Scottish hills, these juicy fruits afford abundant food for moor game.

The Laplanders boil the fruits in alum water, and thus manufacture a dark dye for otter and sable skins. The leaves are interesting and characteristic, for they are not flat, but the edges are bent back, so that a split tube is formed whose inner surface is the lower surface of the leaf. The Crowberry is a dicotyledonous plant, belonging to a special natural order made for plants of the Empetrum genus and its allies, namely Empetraceæ. [A. N. M'A.]

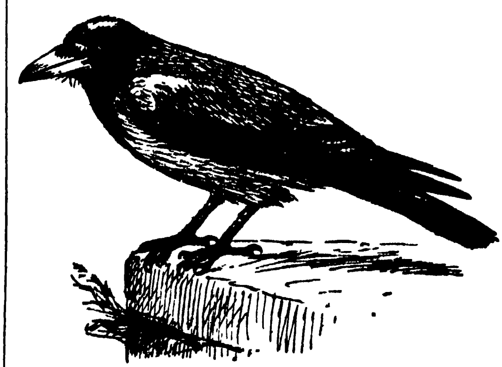
Crowfoot, the common name of the Creeping Buttercup (*Ranunculus repens*). See BUTTERCUP.

Crows.—The name of 'crow' is frequently applied to several birds, one of them being more properly called the Rook (which see); here mention will be made of the Common or Carrion



Carrion Crow (*Corvus corone*)

Crow (*Corvus corone*), and its near ally the Grey or Hooded Crow (*C. cornix*). They both construct stick nests like the Rook, but do not breed in communities. They possess strong, curved, pointed beaks, the feathers of which are not worn away at the base (as in the Rook), and their food is of mixed nature. (1) The Carrion Crow is especially characteristic of England, and migrates south during the colder part of the year, being then largely replaced by the Hooded Crow. It is entirely black in colour,



Hooded Crow (*Corvus cornix*)

with a steely sheen on the back and neck. Stiff bristles at the base of the beak are invariably present through life. This bird is usually seen singly, or in pairs, and nests in late spring, usually in a tree fork. The three to five eggs are of a greenish tint with brown spots. *Food.*—The species is of little agricultural importance, but does harm by devouring eggs (especially those of grouse), or even attacking sickly lambs. This, however, is counterbalanced by its raids on insect and other pests. (2) The Hooded Crow is perhaps only a variety of the Carrion

Crow, with which it is known to freely interbreed. In Scotland and Ireland it replaces its relative for the most part, and towards the close of summer migrates southward into England. The head, throat, wings, and tail are black, while the rest of the plumage is ashen-grey. This bird breeds almost exclusively in Scotland and Ireland, and its nesting habits resemble those of the Carrion Crow, except that the nest is as often built on a rock ledge or on the ground as in a tree. The three to five eggs are of a brownish-green, mottled with brown. It is more sociable than the other species, especially during its southward migration. *Food.*—A small amount of this consists of insects, and the species is so far beneficial, but it is harmful to a far larger extent, devouring the eggs of game birds and poultry, and pecking out the eyes of lambs. An undoubted enemy of the farmer.

[J. R. A. D.]

Crucifer or Cabbage Midge. See CECIDOMYIA BRASSICÆ.

Cruciferæ.—This is the name for a nat. ord. of dicotyledonous plants which includes turnips and cabbages, runch and charlock, &c. The distinctive characters are: (1) The petals are not grown together. (2) The stamens are attached below the ovary, and (3) are 6 in number. (4) The corolla forms a Maltese cross. (5) The ovary is two-chambered. (6) The leaves are alternate, sometimes in a rosette on the ground.

The plants are annual, biennial, or perennial herbs. The number of sepals is 2 + 2, of petals 2 + 2, of stamens 2 + 4, and of carpels 2. The fruit is characteristic. When ripe it is dry, and two valves become detached; there is now left standing a frame with a thin septum stretched across it; the numerous seeds are attached to this frame, and shake off when the plant is disturbed by the wind. Such a fruit has the technical name *siliqua* when it is long, as in turnip, *silicula* when it is short, as in Shepherd's Purse. Sometimes, however, as in Radish and Runch or Wild Radish, the fruit splits transversely into one-seeded joints.

The seed is composed of a skin and an embryo. This embryo is doubled up (1) so that the radicle lies along the edge of the cotyledons, as in Wallflower; (2) so that the radicle lies along the face of the cotyledons, as in Garlic Mustard; and (3) so as to form a globular body, as in the whole tribe of turnips and mustards. In some cruciferous plants the seeds are accordingly quite flat, in others quite rotund and globelike. A wallflower, for example, would be described as a flat-seeded cruciferous plant, whereas a turnip, a mustard, or a charlock would be described as globe-seeded.

Important cultivated Cruciferæ are:—

1. *Fruit a siliqua, seed globose.*—

Cabbages (*Brassica oleracea*).—Varieties are distinguished thus: (*a*) All the buds are open in Kail and Thousand-headed Kail. (*b*) The terminal bud forms a head in cabbage and Savoy. (*c*) The axillary buds are closed in Brussels sprouts. (*d*) The leaf-bearing stem becomes a fleshy tuber standing above the ground in Kohlrabi. (*e*) The inflorescence becomes specially enlarged and fleshy in the hardy Broccoli and the more tender Cauliflower.

Turnip and Turnip Rape (*Brassica Rapa*).—In turnip the so-called root is specially enlarged and fleshy; in rape this enlargement does not occur. Swede and Swede Rape (*Brassica Napus* or *campestris*).—The distinction is similar to that between turnip and turnip rape.

Black Mustard (*Brassica nigra*) is an annual cultivated for seeds. White Mustard (*Brassica alba*) is an annual cultivated for sheep feed, for ploughing in as green manure, and also as a seed crop.

2. *Fruit a silicula.*—Horse Radish (*Cochlearia officinalis*) is a white-flowered perennial cultivated for its rootlike stem, which is underground.

3. *Fruit splitting transversely into one-seeded joints.*—Garden Radish (*Raphanus sativus*) is cultivated for its fleshy so-called root. The flowers are sometimes white, sometimes violet.

Important cruciferous weeds are:—

Garlic Mustard (*Alliaria officinalis*), a white-flowered biennial on hedgebanks. Hedge Mustard (*Sisymbrium officinale*), a yellow-flowered annual of waste land. Charlock (*Sinapis arvensis*), a yellow-flowered annual among corn. Shepherd's Purse (*Capsella bursa pastoris*), a white-flowered annual of arable land Wild Radish or Runch (*Raphanus Raphanistrum*), an annual among corn, usually having yellow petals with violet veins. [A. N. M'A.]

Cruelty to Animals. See ANIMALS, LAWS REGARDING.

Cruickshank, Amos (1808–95), one of the most distinguished of Shorthorn breeders, a man of rare moral worth, undaunted perseverance, and simplicity of character, was born on the farm of Kinmuick, near Inverurie, and died at Sittyton, of which he had been tenant for fifty-eight years. Mr. Cruickshank came of an old Quaker family. In 1837 he, in company with a younger brother, Anthony, then starting on what proved to be a flourishing business career, took a lease of Sittyton, a holding of about 260 ac. on the Straloch estate, some 12 miles north-west of Aberdeen. Other holdings were acquired in course of time, until the whole extent farmed was about 1000 ac. The first Shorthorn was purchased by the older brother in Durham. That was in the fall of 1837. A year later he secured ten heifers in Nottingham. Purchases of good female animals were made in succeeding years at English and Scottish sales. Amos paid little regard to pedigree, and the composition of the herd, even forty years after its founding, was exceedingly mixed. Animals of Booth, Mason, Knightley, Towneley, and to a small extent of Bates and other strains of blood, had place in it. The first bulls used at Sittyton were from the stock of Barclay of Ury. These were followed by generally high-priced and in most cases notable prizewinning sires from the principal herds in the kingdom. Anthony was no doubt largely responsible for the financing of the transactions, but the fate of the animals afterwards lay with Amos. A purchase of far-reaching importance was made by the older brother in December, 1858. This

was Lancaster Comet, an eight-year-old from the herd of Wilkinson of Lenton, in Notts, and inbred to Will Honeycomb. Comet unfortunately became a wreck with rheumatism after a single season's use. One of his calves was the short-legged, heavily fleshed roan Champion of England (17,526), born in November, 1859, and kept in service until he was nearly twelve years old. When the full merits of Champion of England were discovered, his blood was diffused through the whole herd by means of sons, grandsons, and other descendants, until the stock became latterly very much inbred. In its heyday the Sittyton herd numbered about 300 head, and in 1889, when the cattle were acquired by Mr. Robert Bruce for the Messrs. Nelson, who intended to ship the whole for South America, the total was up to 120 head. Owing to financial troubles in the Argentine, most of the Cruickshank stock fell to be disposed of at home. Mr. Wm. Duthie and Mr. J. Deane Willis were the leading purchasers. Until about 1880 Mr. Cruickshank's principal customers for young bulls were Aberdeenshire tenant farmers and Americans. Since 1890 the closely built, thickset, early maturing Cruickshank type of cattle has conquered the Shorthorn world. In the meat-producing sense the debt due to Sittyton has been incalculable. [J. CA.]

Crupper, a looped strap passing under the tail and attached to the harness pad or riding saddle to prevent its forward movement. [H. L.]

Cryptococcus fagi (the Felted Beech Coccus).—This beech coccus has increased so much lately that it has become a serious pest. It manifests itself as dense, felted, white woolly masses on the trunk and boughs of beech trees of all sizes, and in a few years will kill the largest trees. The insect is one of the scale insects. The female becomes surrounded by a white mass of waxy threads. The larvæ are minute, six-legged, active creatures which spread out over the tree during September. The females are yellow masses without legs or feelers, and are quite enshrouded in the balls of white wool; these ovisacs later lay masses of eggs. The male is winged. This pest is distributed by the wind. The result of the constant sucking away of the sap is that the bark peels off, and the wood beneath becomes stained and is valueless. This pest occurs in Northumberland, Durham, Yorkshire, Cheshire, Kent, Surrey, Worcestershire, South Devon, Gloucestershire, the Forest of Dean, Chiltern Hills, &c. *Treatment* consists of cutting down and barking at once isolated trees that show its presence. If trees are of value, then spraying with strong paraffin emulsion or Woburn wash twice at an interval of a few days during the autumn will hold it in check.

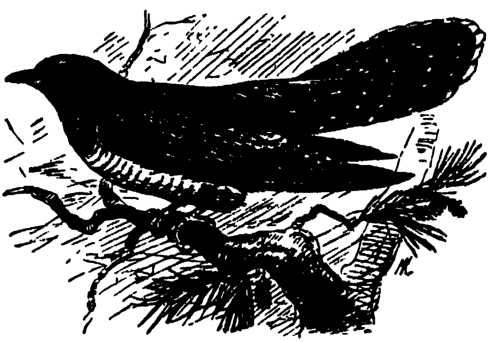
The Woburn wash is made as follows: Soft soap, ½ lb.; paraffin (solar distillate), 5 pt.; caustic soda, 2 lb.; water, 9½ gal. Dissolve the soap in water, churn the paraffin into it, and then shake the soda into it. [F. V. T.]

Cryptomeria or **Japan Cedar.**—Cryptomeria is a genus of the Taxodineæ group of conifers indigenous to Japan, where two species occur. These are both large evergreen trees of an elegant habit of growth, which may be grown in almost any fairly sheltered situation in Britain. Here their distinctive appearance on lawns forms a contrast to other trees, and especially in winter, when the foliage is apt to become brown and discoloured. Their linear leaves are often heteromorphic. (1) The Common Cryptomeria, or Japan Cedar (*C. japonica*), introduced into Britain in 1844, occurs both spontaneously and in cultivation at an elevation of 500 to 1200 ft. in the hilly parts of southern Japan, and generally on damp soil. Its short, smooth, bright-green leaves are five-rowed, sessile, short-pointed, incurved and compressed on both sides of a sharp projecting midrib. Its spreading branches divide alternately into numerous and thickly foliaged branchlets. The globular, dirty-brownish-red cones are about the size of a large cherry, and the ripe cone is somewhat prickly through the cone scales being palmately divided at the edge. The cones mostly stand erect and singly, or else in clusters at the ends of the branchlets, and the seed ripens in the early autumn of the year of flowering. It is a tree of arboricultural interest only here, its white wood being soft and brittle. The largest specimen reported in 1903 (Coollattin, Co. Wicklow) girthed 5 ft. 11 in. (fifty years old), but had lost its top in a gale. The tree can easily be grown from seed or from cuttings. Many varieties are common, some of which turn dull-red in winter. It thrives best on deep, light, moist soil, and in sheltered positions. (2) The Elegant Cryptomeria (*C. elegans*), cultivated to form sacred groves around temples on the island of Nippon, is probably only an arboricultural variety of the above, the foliage of which turns to a rich bronze in autumn. It is fairly hardy, but of course does best in well-sheltered places, and on a rather moist soil. [J. N.]

Cryptorhynchus lapathi (Willow Weevil).—The Willow Weevil is destructive to willows, osiers, aspen, and poplars. It occurs both in Europe and North America. The beetles are deep-brown, and creamy behind, with rough tuberculate appearance. They eat their way into the young stems. The larvæ are white, fleshy, footless grubs which tunnel into the small stems, and their presence can at once be told by the hole and swelling on the stem, with damp wood chips projecting. They feed there all the winter, and quite ruin the stems of young trees and osier rods. The beetles appear in June and July and on to September, and lay their eggs in a scooped-out tunnel; the young larvæ at first tunnel under the bark, and may girdle the stem and also work around the buds; later they bore to the interior and form galleries as much as 4 in. long. They pupate close to the bark in a cell at the end of the gallery in the succeeding year. Rods and small stems are easily broken by the wind and are quite valueless. It appears to have been imported into America.

Treatment consists of cutting and burning attacked rods in osier beds in spring, at least such as show damage, and the pruning out of damaged poplar and aspen. [F. V. T.]

Cuckoo (*Cuculus canorus*, L.).—This familiar migrant reaches us from the south in April (rarely in March), and the old birds leave in August, or sometimes later, being subsequently followed by the young. A cuckoo on the wing looks something like a hawk, which is probably the reason why it is so often mobbed by various small birds. Several eggs are laid singly on the ground at intervals of a week or more, and appear to be carried in the beak of the female to the nest of some small bird, commonly a meadow pipit, pied wagtail, or hedge sparrow, though cuckoos' eggs may be foisted on many



Cuckoo (*Cúculus canorus*)

other species (some sixty in all). They vary greatly in colour, and sometimes, but by no means always, resemble those of the victim. That the young cuckoo shoulders its foster-brothers and sisters out of the nest, aided by a depression between its shoulders, is a matter of common knowledge, and the unremitting attention paid by the foster-parents to their unnatural guest is undoubted. The adult Cuckoo is purely insectivorous, and is particularly partial to hairy caterpillars, which other species reject. It also destroys large numbers of sawfly larvæ. Harm is done, on the other hand, by the immolation of nestlings belonging to useful small birds. But the good largely outweighs the harm, and there is no reason for persecuting the species. [J. R. A. D.]

Cuckoo Pint. See ARUM MACULATUM.

Cuckoo Pint (Meadow). See LADIES' SMOCK.

Cucumber.—This plant (*Cucumis sativus* —see art. CUCURBITACEÆ), differing from the other members of the genus in its peculiarly long and narrow fruits, and supposed to be a native of southern Asia, was cultivated by the ancient Egyptians, and has been extensively grown and highly esteemed in those countries suitable to it. Indeed, it is in many places quite an important article of food, the young fruits, which are known as gherkins, being pickled in Russia and other northern countries to a much greater extent than is the case here. The cultivation of the Cucumber was widely practised and much discussed in this country upwards of a hundred years ago, but the heating arrangements required for the production of the superior sorts were greatly inferior to those now in vogue, and, thanks to the coming of the modern system of market gardening under glass, the industry of cucumber growing has within the last twenty years attained to dimensions previously unthought of. Fine cucumbers are now upon the market all the year round, but it is more usual to sow seeds for the first crop in February, and to cease cutting in October. The Cucumber requires the best-quality loam, cut in turves about 4 in. deep, and stacked for a few weeks or longer with alternate layers of horse manure. The plants are trained up wire trellises on the roofs of narrow span-roofed houses, the usual planting distance being 3 ft. apart. An exceedingly moist forcing temperature is maintained throughout, and the trade has suffered a good deal of late from outbreaks of a fungoid disease known as Cucumber Leaf Blotch (*Cercospora melonis*—see next art.), due to the extreme susceptibility of the plant under this so-called 'Express' cultural system. Four dozen fruits to the plant is considered an average crop by the market grower. Equally good-quality cucumbers are produced in frames heated by hot beds in the summer months, while the inferior or ridge kinds are cultivated entirely out-of-doors. Of the great number of frame kinds, Rochford's Market and Peerless are among the very best. [W. W.]

Cucumber. — Parasitic Fungi. — Downy Mildew (*Plasmopara cubensis*), one of the Peronosporeæ (see FUNGI), forms first a white mildew on cucumber, melon, and other cucurbitaceous plants, later the foliage becomes yellow and dies. Powdery Mildew (*Erysiphe*) occurs as whitish patches bearing chains of spores (see ROSE MILDEW); this fungus is generally superficial, and does not cause yellowness of the foliage. Leaf and Fruit Spot arise in various ways, but the most destructive form in Britain is generally ascribed to *Cercospora melonis*, which gives rise to pale-green spots turning to greyish-brown; the elongated and club-shaped sporules are borne on upright brown filaments; when the attack is severe, the leaves wither rapidly and the fruits are also injured. Sudden failure of whole plants is not uncommon, but the cause is still obscure. Root-gall is caused by Eelworms.

Treatment. — Forced cultivation with much manure, and warm, moist conditions, are extremely favourable to the growth of fungi, and it is quite usual to find several fungi at once on a diseased plant. It therefore remains with the grower to devise a system of cultivation by which such conditions will be avoided. The collection and burning of dead and fallen leaves will assist in checking propagation. Spraying has been suggested, but some growers question its efficiency. Some success attended resting cucumber houses for a year, during which they were carefully washed and limed, and supplied with fresh soil. Treatment with sulphur vapour has also been recommended; also sprinkling the paths with carbolic acid (Calvert's No. 5, 1 pt. in each 5 qts. of water). It seems, however, that measures such as these only check for a short time diseases which are primarily due

to the conditions of cultivation necessary to produce early crops. [W. G. S.]

Cucurbitaceæ.—This is a nat. ord. of dicotyledonous plants which includes the well-known Cucumber. The distinctive features are these: (1) Two kinds of flowers, male and female, are present, the latter kind, of course, being the fruit maker. (2) The ovary is on the outside of the flower. (3) The base of the corolla adheres to the calyx. (4) The five anthers are sinuous and ∽ shaped, united in pairs or all grown together. (5) The plants are juicy herbs, climbing by tendrils placed at the side of the leaf. Many annual plants of this order are cultivated for their large thick-skinned berries; such a berry fruit is technically called a pepo.

The most important cultivated plants are: Cucumber (*Cucumis sativus*), with simple tendrils which represent bract leaves, and a long pepo fruit. The female flowers are solitary and can develop the fruit (pepo) *without fertilization*. Melon (*Cucumis Melo*), also with simple tendrils, but the pepo is globose. Vegetable Marrow or Pumpkin (*Cucurbita Pepo*), with branched tendrils, and a pepo containing seeds with a *swollen* margin. The tendril here represents a shoot, and its side branches, lateral shoots. A poisonous perennial climbing hedgeweed of this order is Bryony (*Bryonia dioica*), with red thin-skinned berries about ¼ in. in diameter. [A. N. M'A.]

Cudweed, or **Marsh Cudweed** (*Gnaphalium uliginosum*), is one of the Composites belonging to the division *Diversifloræ* with two kinds of flowers in the head. It is an *everlasting*, and marked as such by the dry coloured involucre surrounding the head of flowers. The species in question is a much-branched annual marsh weed seldom above 6 in. high; it has a white appearance because of the cottony hairs which cover its surface. The flower-heads are only ⅛ in. long; they have a brown involucre, and are crowded together within tufts of narrow lance-shaped leaves. The plant grows on wet, sandy situations. Another species of Cudweed, called Highland Cudweed (*Gnaphalium sylvaticum*), is a common perennial weed on heaths and moorland pastures. The heads are larger, ¼ in. long, and not compacted together, but arranged in the form of a long leafy raceme. [A. N. M'A.]

Culex pipiens (Common Household Mosquito or Gnat).—The Common Household Mosquito is a brownish fly with pale bands at the bases of the abdominal segments. Like all mosquitoes, it is provided with a long, sharp, piercing mouth, by means of which it sucks up the blood of animals and man after puncturing the skin, or the sap and juices of plants and fruits. The females alone are sanguinary, and can be told from the males by the latter having long palpi and plumose antennæ. They deposit their eggs in packets ('rafts') on water; the young larvæ ('wrigglers') escape from the lower surface of the eggs into the water, where they pass all their time. The larvæ are very active, and have a long respiratory siphon on the eighth segment of the abdomen, the tip of which is now and then passed through the surface film so as to obtain air. The pupæ also swim about; they have two horns for respiration on the thorax, and when the gnat is ready to hatch they come to the surface, and the pupal skin forms a kind of raft, from which the gnat eventually flies. The adults hibernate in cellars and outhouses. An allied species in the Tropics and sub-Tropics (*C. fatigans*) is the intermediate host of the Filaria worms which cause 'elephantiasis'.

They mainly breed in water barrels, cisterns, and pools, and may be destroyed by putting a small quantity of paraffin oil on the surface of the water. [F. V. T.]

Culm Measures.—The word 'culm' was applied to the dust or slack of anthracite, and thence to anthracitic coal itself. In Germany, the name 'Culm Measures' is given to any beds of terrestrial origin with coal seams occurring below the true Coal-Measure series (see art. CARBONIFEROUS SYSTEM). In Britain, the term is restricted to the exceptional type of Carboniferous strata in the south-west of England. These beds range over a wide area in Devonshire and northern Cornwall, and are marked by their comparative poverty in limestones, and by the prevalence of slates, shales, and sandstone, with some layers of flint. They correspond below to the Carboniferous Limestone and Pendleside series of more northern areas, and their upper beds, containing a few seams of anthracite, may run as high as the Middle Coal Measures. These strata form a rugged coast with bold headlands, and the inland plateaus are often of a moory type. Even the occasional lenticular limestones are sandy and unsatisfactory for burning for lime (see H. B. Woodward, Geol. of England and Wales, 1887, p. 200), and the soils resemble those of our more siliceous mountain areas. [G. A. J. C.]

Cultivation.—Cultivation ordinarily involves ploughing to invert the first few inches of soil, so that a fresh layer may be brought under the direct influence of air, frost, rain, and other climatic forces, which will tend to reduce it to a friable condition; also to pare off a sufficient layer to enable the implements which follow it to work more freely and effectively. Occasionally land is not ploughed, but stirring implements such as cultivators first tear the top section from the subsoil, and other lighter implements follow, which ultimately reduce the surface to the required condition; this, however, is advisable only under special circumstances. Cultivation for a special purpose may be effected almost entirely by the plough, as in the case of a dead fallow on heavy land, where the object is to clean the land of couch and other weeds. Were the soil to be allowed to be brought to a finely divided condition, cleaning might be impossible should wet weather prevail for a period, for the soil would run together again, and the couch re-establish itself, and it would be impossible to clean the land without dragging out all the couch—a most difficult process, as once the land has become saturated when in a fine condition, each fresh rain makes it impossible to put horses on it for some time. If, however, the land is ploughed when stiff, and

then allowed to dry, hard bricklike clods will form, and the air will circulate freely round them, so that in a period of dry weather the couch will be killed. By occasionally ploughing in fine weather the moister underside will be brought to the top, and such pieces of couch as are still living will be killed. This is what is known as 'cleaning the land in the clod', and is employed where the land has a tendency to become sticky when wet. Where, however, the soil is naturally of a friable nature and dries quickly after rain, cleaning is most commonly effected by reducing it to a fine condition and dragging the weeds to the surface, and either collecting them or keeping them constantly turned by harrows to kill them on the surface.

Cultivation to procure a fine seedbed is ordinarily effected by employing heavy implements to reduce the clods, and gradually using lighter ones as the clods become smaller. Land may be said to be worked 'up' to a tilth by stirring implements, and 'down' to a tilth by rollers and clod crushers. The nature of the soil and the state of the weather largely control the desirability of using one or other of these types of implement, or of both; but a far better seedbed is obtained where it is secured without crushing than with it; and good management in the early operations and the skilful seizing of favourable opportunities mark the difference between a skilful and a clumsy tiller. Still, the finest skill is shown during the final operations, as on them depend the control of moisture which is so important to the germination of the seed and the proper establishment of the plant. This is especially so in connection with corn sown in the spring, grass and clover seeds, and seeds of root crops, because if these are sown too deeply they may be unable to push their shoots above ground, and if too shallow, moisture may not be held closely enough to the surface to surround them so as to cause germination The fineness of the seedbed must therefore be in close relation to the size of seed; and the tightness or looseness of the soil must be regulated according to the moisture and the condition of the weather, as it is the capillary moisture in the soil which has to be controlled; consequently the final operations of cultivation must be guided by the conditions enumerated, and it requires good experience and judgment to know whether it is advisable to leave the land rolled down or harrowed up. Failure to discern which is best causes 'failure of plant' to occur in innumerable instances where no such failure need occur, and by it the effect of good cultivation during the earlier operations is entirely lost. (See next art.) [W. J. M.]

Cultivation, Chemical and Physical Effect on Soil.—The object of cultivation is to make the soil conditions as favourable as possible for the plant at all stages of its growth. If the plant requirements change, fresh operations may be necessary; if the soil has been altered by the weather or other cause, it must be brought back to a proper state by suitable means.

Plants require water, air, a suitable temperature, food, absence of injurious substances, and support for the roots. All these factors are influenced by cultivation, and the success of the crop depends on how nearly they can be kept to the most favourable condition.

The amount of water needed for plant growth has been variously estimated, but it appears that an average crop of cereals, hay, and roots will require about 600 tons per ac., equivalent to 6 in. of rain, while a 30-ton mangold crop requires about 10 in. The average rainfall at Rothamsted during the months May, June, July, and August is 10 in., and so much of this runs off the land, drains through, or evaporates, that the amount actually available for the crop is not great; the crop is therefore dependent for its water supply on rain which has fallen during the preceding months. February, March, and April constitute the driest period of the year, the total rainfall during the three months being less than 6 in.; the chief water supply comes from the autumn and winter rain, and this has to be kept in the soil till the summer. We shall find that most of the tillage operations in common use have the effect of increasing or conserving the water supply.

Water, air, and temperature are all intimately related; if there is excess of water, the air supply will be deficient and the temperature too low; if, on the other hand, the soil is over dry, the temperature may rise too high. All three are bound up with tilth; when this can be kept right, the air, water, and heat supply will usually be satisfactory. Unfortunately so little is known about the physical causes of tilth that a complete discussion is impossible. It is certain that a good tilth cannot be obtained if there is either too much or too little water. Excess renders all but the lightest soils sticky; any attempt to work them when in this state is likely to do a great amount, sometimes an almost irreparable amount, of harm. As the soil dries it reaches a stage when it is readily broken down to the proper crumbly condition, and suitable working will now give a satisfactory tilth. The effect of allowing the soil to become too dry varies somewhat. A stiff clay dries to hard, intractable clods which resist all attempts at breaking down; certain loams become very steely; soils with small amounts of coarse sand tend to form crusts; and sandy soils with insufficient clay may fall to powder. In none of these cases can a good tilth be obtained till the soil has again become sufficiently moist.

Food may either be added in the form of manure, or derived from the soil itself; in either case a sufficiency of moisture is essential, because the plant takes all such food in a soluble form. The activity of micro-organisms is necessary in order that the soil may yield its full share of food; they are present in enormous numbers, and are, as a rule, favoured by the same conditions as plants; the same considerations therefore apply to both.

There are, however, organisms present which are inimical to plant growth, and at least two important types of action are known. They are: (1) *denitrification*, or the decomposition of nitrates, indirectly harmful because it robs the plant of valuable food; and (2) certain *putrefactive changes*, which appear to be directly injurious on

account of the poisonous nature of the products formed. The organisms involved are known as *anaërobic*, *i.e.* they will not work if air is present, and their harmful action is minimized by letting in sufficient air. Even when injurious substances have actually been formed, they are often decomposed in contact with air, and, if we except the cases dealt with under Alkali Soils, it is a general rule that thorough aeration materially helps in keeping a soil free from injurious substances.

Root hold is only secured when the soil is sufficiently compact. The process must not be carried too far or it will interfere with the air and water supply, but a proper hold is obviously a fundamental condition of the plant's existence.

Drainage.—The position of the water level is the limit below which root growth does not normally take place. Above this level, air can get in, and render possible the development of the roots and the activity of useful organisms; below it the type of bacterial action alters, and the beneficial aerobic changes are displaced by the harmful anaërobic processes already described. To say that plant roots cannot grow in water would not be quite correct, since water cultures of most plants are easily made, but the roots so formed are not normal, and the water-logged part of the soil is useless for root development.

As soon as the soil is drained, the water level is lowered, and the plant roots need no longer remain close to the surface, but can strike further into the ground till they are again stopped by the new water level. In other words, the depth of the soil is increased. There are many attendant advantages. Instead of the restricted flora previously possible, a larger variety of plants can be grown. It is found, too, that plants are much less likely to suffer from drought, a rather paradoxical result, but one which always follows an extension of the root range, since the lower depths of soil remain cool and moist in hot weather for a much longer time than do the upper layers.

These results are not obtained at once, they come only when air can sufficiently easily penetrate the soil, and two sets of causes operate to this end. There are various purely mechanical causes. Air can now enter through the drain pipes and gradually diffuse into the soil. Earthworms can go farther down, making deeper burrows than before, and each burrow constitutes a passage along which air can enter. Plant roots go deeper, and, as they decay, spaces are left which permit the entrance of air. The second set of causes are more deep-seated. The newly drained portion of the soil usually contains much deflocculated clay, which greatly impedes the movement of air and only slowly improves in texture. Some shrinkage, and consequent improvement, takes place as the excess of water drains away, but perhaps the greatest improvement follows from the flocculating action of the calcium bicarbonate almost always present as it percolates through to the drains. These changes are all hastened by deep cultivation and liming.

Freer access of air, besides benefiting the root system of the plant, also influences the bacterial processes. Humification, nitrification, and other beneficial changes are now hastened, and injurious substances accumulated whilst the soil was water-logged become harmless by oxidation.

It has already been remarked that the water, air, and temperature relationships of soils are closely connected, and the improvement brought about by drainage in the water and air supplies is accompanied by a rise of temperature. One pound of water requires more heat to raise its temperature one degree than any other ordinary substance, and the extent to which a day's sunshine will heat a soil depends more on the amount of water present than on anything else. This point is discussed more fully under Soil, Physical Properties of; for our present purpose it suffices to note that a dry soil is warm and early, and a wet soil cold and late. Actual temperature readings were made many years ago by Parkes of the drained and undrained portions of Red Moss, Lancashire (Journ. Roy. Agric. Soc. 1845, p. 140); the drained part was found to be 10° to 19° F. warmer than the undrained, and the difference in temperature was distinct even at a depth of 31 in below the surface. Later determinations, made by King (The Soil, p. 227) give very similar results. A comparison of the temperatures of a well-drained sandy loam and an undrained black marsh soil gave the following figures:—

	April 24th.	April 25th.	April 26th	April 27th.	April 28th.
Temperature of drained soil .	66·5° F.	70·0° F.	50·0° F.	55·0° F.	47·0° F.
Temperature of undrained soil	54·0°	58·0°	44·0° F.	50·75°	44·5°
Excess, drained soil	12·5° F.	12·0° F.	6·0° F.	4·25° F.	2·5° F.

Ploughing.—The combined effect of spring cultivation and of rain on the soil is to produce a settling of the particles, and by autumn the surface layer has become too compact for the growth of a new crop. It is therefore necessary to loosen the soil by digging or ploughing. How great the effect is may be readily seen by comparing the height of the soil on the land side with that of the turned furrow slice.

This loosening action is further intensified by frost. As the water in the soil freezes it expands and pushes the particles apart, so that when the thaw sets in and the excess of water has drained away, empty spaces are found which did not before exist. A good illustration of the separation thus brought about is furnished by the case of bulbs planted near, but under, the surface of the soil: after a frost they are often

lifted right out and exposed to the air. A similar thing may happen to young plants. The effect on the soil is to increase its volume, to lighten it, and all types of soil are acted on in the same way. Indeed the south-country chalk farmer will often consider that a succession of frosts makes his soil too light. But on medium and heavy soils this action is an essential preliminary to a good spring tilth.

Frost has several collateral effects. It helps to disintegrate the stubble and roots of plants; the expansion caused by the freezing of the water they contain splits them up, so that they are much more readily attacked by soil organisms. For the same reason, mangolds and swedes which have been pulled and are being stored must be protected against frost if they are to be kept good.

Soft material saturated with water, like chalk lying on the surface of the ground, is shattered by frost, and can now be readily spread about to exert its maximum effect on the soil. No doubt the same thing happens to the hard coarse particles and stones present, but to what extent this goes on, and whether any appreciable quantity of food is liberated thereby, are questions one cannot yet answer.

Autumn ploughing leads to an increased percentage of water in the soil. King found that a piece of land which had been ploughed in autumn and left undisturbed till the following May then contained in the top 3 ft., 2·3 per cent more water, or over 100 tons per acre, than an unploughed piece. Hall obtained a similar result at Wye. The cause is not far to seek. Except when the land is very light, rainwater cannot easily penetrate the soil in the compact state in which it is generally found after harvest, but either lies in pools on the surface, to be lost by evaporation, or else flows off into the ditches. Into ploughed land, on the other hand, rain can soak without difficulty, and even if heavy storms come, the broken surface checks the flowing off of water, and retains it till it has had time to soak in. These effects are readily seen after ploughing has been interrupted by rain. The ploughed land is moist but not water-logged at the surface, because the water has found its way below, while the unploughed land shows every sign of excess of water at the surface, indicating that less has penetrated.

Besides securing an extra supply of water, the ploughed land can preserve its stock better. There is less evaporation, since the loose soil acts as a mulch (see below, 'Hoeing'). Moreover, soil in the loose, crumbly condition induced by ploughing and frost holds more water than compact soil, just as a sponge holds more water when loose than when squeezed.

Light soils require somewhat special treatment. Water soaks in without difficulty, and in dry districts, *e.g.* the south-eastern counties of England, the trouble is to prevent it being lost by evaporation or percolation. Evaporation can be checked by the expedient adapted by chalk farmers of setting the mouldboard to turn the furrow slice right over (see below, 'Ridging'). Loss by percolation is much more serious, and two methods are in use for dealing with it, both depending on the fact that a compact soil allows less percolation than a loose one. On the light chalk soils of the North and South Downs, where there is no tendency to pan formation, the subsoil is made more compact by folding or by working with a heavy plough, and the old wooden plough is still in common use. Very light sands are often left uncultivated throughout the winter, their compact condition not being disturbed. The presence of weeds during this period is of some advantage, because they take up soluble plant food and prevent it being washed away.

Ploughing also causes a very perfect aeration of the soil. The advantages of early ploughing, on all except light soils, may be summed up in the light of the above considerations as follows:—

1. There is more chance for early frosts to act, and frosts intensify the effect of ploughing in producing tilth, &c.

2. October, November, and December are the wettest months of the winter, and ploughed land holds water better than unploughed.

3. Aeration is more perfect, because it goes on longer. The effect of ploughing when land is wet is discussed in the art. PLOUGHING.

SUBSOILING.—Subsoiling is a modified and less efficacious form of trenching; it has the same effect, but to a less extent. Both may be regarded as a sign of intense culture. Trenching is almost solely a garden operation, and subsoiling is generally adopted for valuable crops like potatoes, &c. The effect on the subsoil is precisely the same as that of ploughing on the surface soil: the total result of ploughing and subsoiling is therefore an intensification of the effects just discussed. The subsoil becomes looser, so that trenched or subsoiled land is always higher than adjoining untouched land. Frost gets farther in, and the depth of soil which will finally be available for plant roots becomes much greater. This extra root range would be beneficial even if the soil gained no moisture or plant food, but as a matter of fact it gains both.

It might be thought that subsoiling would decrease the water supply by allowing water more readily to run away into the depths of the soil. This, however, is not the case. King supplied known amounts of water to two plots of ground, one of which had been subsoiled, the other not. They were covered so as to prevent evaporation, and after a time the amount of water present in each plot was determined. The quantity originally present was then deducted to give the amount each plot had gained. The results were—

Total water added = 254·41 lb.

	Subsoiled plot.	Plot not subsoiled.	Difference in favour of subsoiling.
	lb.	lb.	lb.
1st foot of soil gained	124·6	102·1	22·5
2nd ,, ,,	72·57	10·34	62·23
3rd ,, ,,	38·22	12·05	16·17
4th ,, ,,	33·26	3·82	29·42
5th ,, lost	2·29	19·5	17·21
First 4 ft. gained	268·65	128·31	140·34

The whole of the added water remains near the surface in the subsoiled plot, whilst half is lost from the other. Similar differences were observed when evaporation was allowed to take place freely for seventy-five days from June to September, the land being kept uncropped. The percentage of water in the successive depths was found at the end to be—

	1st foot.	2nd foot.	3rd foot.	4th foot.	5th foot.
Subsoiled plot	17·07	23·29	22·76	16·35	18·14
Plot not subsoiled	18·91	19·42	17·78	14·19	19 20
Difference in favour of subsoiling ..	- 1·84	+ 3·87	+ 4·98	+ 2·16	- 1·06

Difference in first 4 ft. in favour of subsoiling, 9·17 per cent.

Subsoiling allows air to penetrate more deeply into the soil, and therefore causes an increase in the beneficial aerobic bacterial changes. More plant food is produced, and oxidation goes on more freely.

The beneficial effect on the crop is great. Indeed in the early years, when wages were low, subsoiling or trenching was suggested as a cheap way of growing wheat without manure; the historic method devised by the Rev. C. Smith, of Lois Weedon, is discussed under SOILS.

Soils liable to pan formation should be subsoiled sufficiently often to keep the pan broken, for, like a water table, a pan represents the limit beyond which most plant roots will not grow.

Warm spring rains raise the temperature of the soil in the early part of the year, and any operation like subsoiling, which enables them to penetrate more readily, necessarily increases their warming effect.

SPRING CULTIVATIONS.—It is shown in the article on soil physics that 'surface tension' or 'capillary action' causes water to travel upwards to the surface more readily in fairly compact than in loose soil. A layer of loose soil, therefore, checks the capillary movement of water; water can rise through the compact soil, but cannot rise into the loose soil above. It is also proved that loose soil does not conduct heat as well as compact soil; a layer of loose earth, therefore, helps to keep the ground cool in summer. In consequence of these two properties, a layer of loose earth reduces evaporation from the soil, and tends to conserve the water supply; we shall find that most of the operations of spring and summer cultivation aim at producing such a layer at as early a date as is necessary.

CROSS-PLOUGHING.—In the south-east of England, and in other places where low total rainfall and dry spring months necessitate careful conservation of the soil water, it is customary to cross-plough in spring at as early a date as possible. This early stirring partially dries the surface soil, and therefore makes it more readily reduce to a fine tilth, while the loose layer thus produced checks further loss of water.

One of King's experiments illustrates this well. A piece of land was ploughed on 29th April, and a week later the amount of moisture present was determined and compared with that present in some adjoining unploughed land. The results were:—

	1st foot	2nd foot.	3rd foot	4th foot.
Pounds of water in—				
Ploughed land . .	13·87	20·66	18·32	16·05
Unploughed land . .	10·58	17·98	17·28	13·94
Difference in favour of ploughing	3·29	2·68	1·04	2·11

Total difference = 9·13 lb. per square foot, equivalent to 1¾ in. of rain, or nearly 200 tons of water per acre (The Soil, p. 188).

HARROWING is chiefly mechanical in its effect; by breaking down large lumps, it aids in getting the soil into a fine, loose condition. King (The Soil, p. 192) has shown that where the soil is already in loose condition, harrowing may, under some circumstances, actually cause loss of moisture.

It is essentially a tilth-producing operation, and we have already pointed out that a satisfactory tilth is usually associated with satisfactory air and water supplies. Moreover, a fine tilth is favourable to a large root development, since it enables the plant root to travel in all directions.

ROLLING, like harrowing, is probably mainly mechanical in its action, especially when the object is to reduce clods to a finer powder, or to break the crusts that form on certain soils after rain.

Recourse is also had to rolling to bring the soil particles into closer contact with the seed or young root, in order to secure sufficient water supply, or, in the latter case, to secure proper root hold. Two important results follow: (1) the temperature of the ground is raised, since compact soil conducts the sun's heat better than loose soil; (2) water is brought to the surface more rapidly from below.

King's temperature measurements, taken on spring afternoons at eight Wisconsin farms, gave the following average results:—

Air temperature		Soil temperatures. Rolled ground	Cultivated ground.	Difference in favour of rolling.
65·4° F.	1½" deep	71·7° F.	68·6° F.	3·1° F.
	3" ,,	67·3° F.	64·4° F.	2·9° F.

The increased movement of water to the surface causes some loss, but in the early stages of the plant's life it is all-important that the water supply should be sufficient to prevent any undue check, and this end must be attained even at the expense of some of the soil water. The effect of the increased water supply is well seen on grass land. It is commonly noticed in pastures on light or medium land that the grass is greener and healthier-looking where the soil has got pressed down, either by treading or by a cart track, than elsewhere; in fact, spring rolling is a well-recognized operation on grass land. Rolling is, of course, only practicable on arable land when the ground has been dried by previous cultivation (see art TILTH).

HOEING OR CULTIVATING.—The effects of hoeing fall under four heads: (1) an increased amount of air is introduced into the soil, (2) the movement of water is modified, (3) the temperature of the soil becomes less liable to fluctuation, (4) weeds are kept under.

1. *Increase of Air Supply.*—The increased air supply is a mechanical effect, caused by the stirring up of the ground. It reacts on the activity of the soil micro-organisms, and in consequence the production of plant food, especially of nitrates, increases, so as to become an important factor in the growth of crops like swedes and turnips, which get a good deal of summer cultivation. Experimental results are given below under 'Fallowing'. A further consequence is that other oxidations readily go on, and the soil is therefore kept free from a number of substances injurious to plant growth. The effects described below are all favourable to increased bacterial activity.

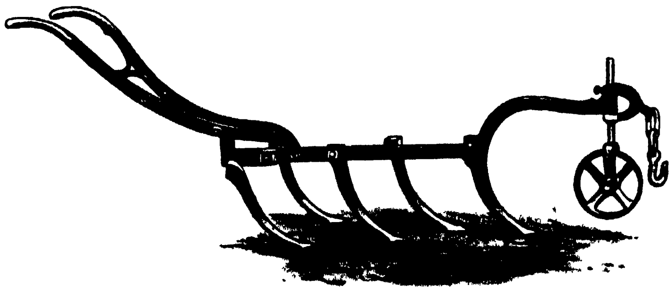
2. *Effect on the Water Supply*.—The surface layer of soil tends to become dry by hoeing, but the dry layer so formed prevents further loss of water, partly because it checks the movement of water to the surface, and partly because it keeps the soil cool during hot weather. Further, the improved tilth consequent on frequent hoeing increases the water-holding power of the soil (see above, 'Ploughing'). Hoed or cultivated land is, therefore, invariably moister than untouched land. In one of King's experiments (Wisconsin, 8th Report, p. 105), a field which had been ploughed and harrowed in spring was divided into alternating strips each 12 ft. wide. One set of strips was rolled on 14th May and then left alone except to remove weeds, the intermediate ones were cultivated frequently to a depth of 3 in. The percentages of water found at different depths during the summer were as follows:—

	1st foot.		2nd foot		3rd foot.		Total gained by cultivation
	Rolled	Cultivated.	Rolled.	Cultivated.	Rolled	Cultivated.	per cent.
May 29 ..	15·4	17·2	16·6	16·4	14·5	14·3	1·4
June 9 . .	13·6	16·9	13·7	15·8	14·3	14·1	5·2
June 17 .	12·0	16 0	14·1	16·1	14·5	14·4	5·9
June 20	15·0	19·0	14·8	16·8	14·6	14·0	5·6
July 17	11 8	14 1	14·2	15 9	13·9	14·6	4·7

3. *Effect on Temperature.*—It has already been pointed out that loose soil is a worse conductor of heat than compact soil, and hoeing therefore tends to maintain an equable soil temperature, which is, on the whole, beneficial to the crop. During spring and early summer, however, the effect is harmful, because it prevents the sun's heat from passing into the soil: this seems to be its one bad result, and at this period hoeing is displaced by the converse process, rolling (see above). During hot weather the effect is good, because it reduces the difference between day and night temperatures. In the autumn it is also good, because it diminishes the rate at which the soil cools, so that the hoed ground has now a higher temperature than untouched ground, and plants can go on growing longer, an obvious advantage in the case of fallow crops, fruit trees, &c.

4. *Effect of keeping the Ground free from Weeds.*—Weeds act injuriously by taking food, and especially water, required by the plant, by depriving it of some of the space available for root formation, and, in extreme cases, by shutting out light. No cultivated crop can stand against the competition of weeds. In 1882 a part of the Rothamsted wheat land was left unharvested to seed itself. In 1883 a fair amount of wheat came up, but as the season advanced it got weaker, owing to the competition of weeds. For the next two or three years there were only very few wheat plants, and they were stunted, and almost unrecognizable, producing only two or three grains in the ear; since then no wheat has appeared, but only weeds and grass. Even grasses cannot compete well against weeds. When the first botanical examination of the unmanured grass plot was made in 1862, it was found that weeds formed 21 per cent of the total herbage; in 1906 they formed 46 per cent.

CULTIVATORS—I



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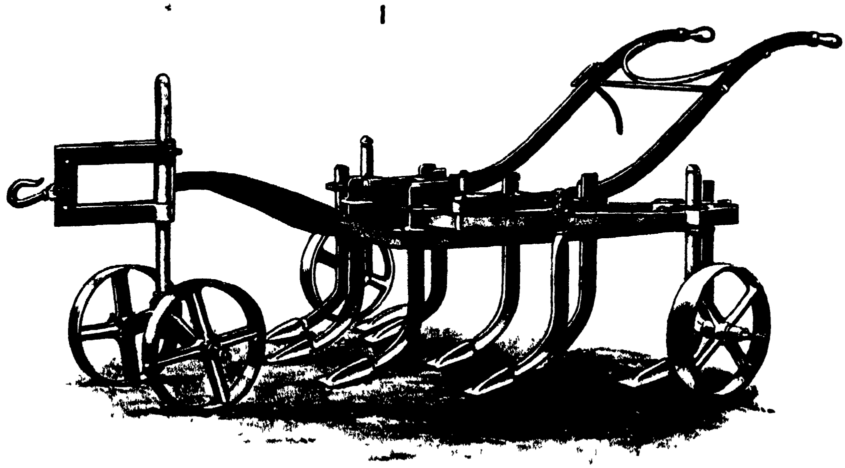

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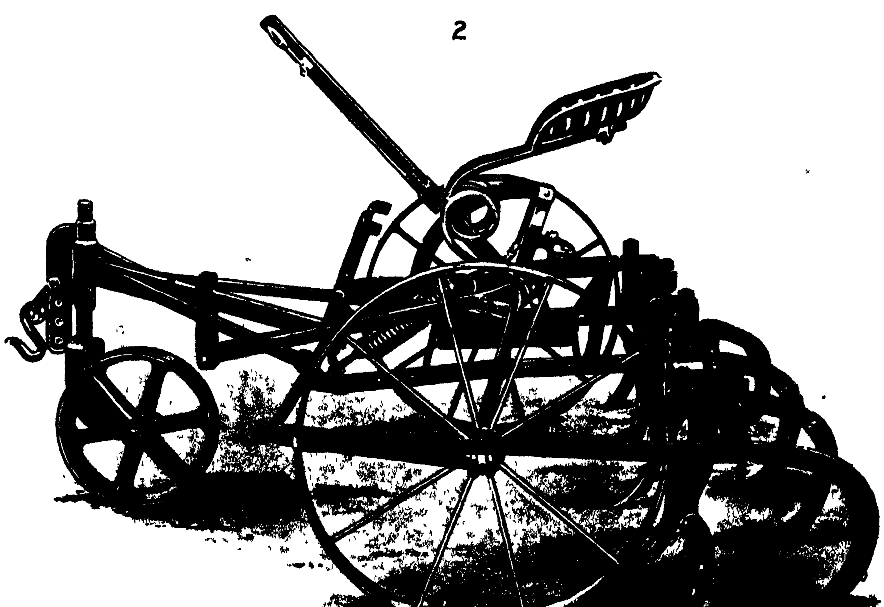


3

1, Jack's Five-tined Drill Grubber. 2, Ball's Scuffler. 3, Wallace's Universal Cultivator.

"DRYLAND" CULTIVATION.—We can now see the necessity for the operations adopted in arid regions, where the rainfall is low. These operations include deep ploughing, followed by harrowing, so as to get the soil into a fine state. As a rule the harrowing is repeated after each rain, and when the crop is up the surface soil is frequently stirred. All these operations keep the water in the soil, and prevent it being lost by evaporation.

FALLOWING.—The considerations set out above hold also for fallowing, since this is practised in order that summer cultivation can be more readily carried on The increased air and water supply leads to greater bacterial activity (see above), and as there is no crop on the ground the extra nitrates formed are not taken up by plants but remain in the soil, to come in for the succeeding year's crop. Some of Warington's results are as follows:—

NITRATE IN POUNDS PER ACRE TO DEPTH OF 18 IN. (SEPT. 1878).

	Cropped ground.	Fallow.	Difference in favour of fallowing.
Agdell field, complete manure	20·5	48·8	28·3
Agdell field, superphosphate only	10·6	36·3	25·7
Hors field, unmanured	2·6	33·7	31 1

The crop in the first two cases was beans, in the third, wheat. Of course, if the autumn and winter turn out wet, the nitrates may wash too far into the soil and be lost to the plant, so that the succeeding crop gains little or nothing by the process. Comparing the yield of wheat after fallow with that of wheat after wheat at Rothamsted, it is found that fallowing causes an increase of about 50 per cent when the autumn rainfall is below the average, and only 8 per cent when it is above.

Liebig attributed the beneficial effects of fallow to the increased production of mineral food, but Lawes and Gilbert pointed out as early as 1856 (Jour. Royal Agric. Soc. 1856, p. 617) that the increased availability of the nitrogen was the determining factor.

A summer fallow gives excellent opportunities for cleaning the ground, and the advantages of being free from weeds have been already stated.

In dry climates there is the further advantage that a certain amount of water is saved for the next crop, but in moist climates like our own this advantage disappears.

MULCHING is a garden rather than a farm operation. The mulch acts in the same way as the layer of dry soil in hoeing, *i.e.* by protecting the ground against loss or gain of heat, and by reducing evaporation. It keeps the ground cool in spring and warm in autumn; in winter it keeps off frost, which would not only improve the tilth, but also kill a number of pests.

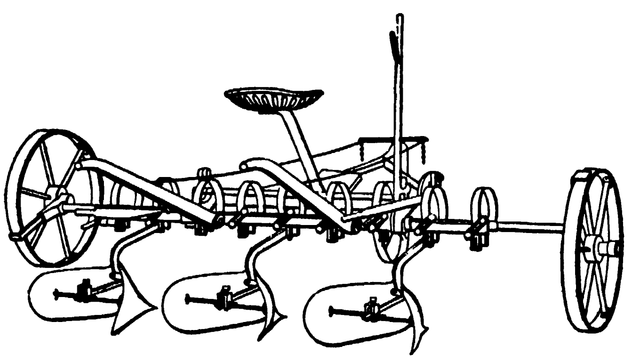
RIDGING acts in two ways: (1) the part where the crop grows is raised, and therefore drainage is facilitated; (2) the surface of the land is increased. The first of these has already been discussed under 'Drainage'; the second leads to increased evaporation of water, and to an increased temperature, especially if the ridges run east and west, with slopes facing north and south respectively. This method is therefore adopted when the water supply is too great and the temperature is too low for the crop; in the converse case cultivation on the flat is preferable.

[E. J. R.]

Cultivators.—Improvement in agricultural machinery is as well marked in cultivators as in any class of implement. The past century has witnessed the transition from the wooden frame to the iron frame and to the steel frame, in fact to the all-steel cultivator; while the effectiveness and diminution in draught have been vastly improved, and cultivation rendered more easy and far less expensive. Cultivators are ordinarily regarded as being included in those implements which are used to perform the heavier acts of tillage, and a distinction between them and harrows is that they are generally carried on wheels, whilst harrows are wheelless; the one being carried on a wheeled frame, by which the depth of the work can be regulated, and the other without wheels, relying entirely on its weight to force the tines into the ground. Modern introductions have, however, somewhat disturbed this classification. Different nomenclature is employed in different parts of the country; and what is a cultivator in one, in another may be a scuffle or scuffler, scarifier, grubber, drag, shim, &c., while the smaller or lighter ones are known as wheeled drag harrows, shims, nidyats or nidgets, &c.

The earlier wheeled cultivators, in spite of their wheels, depended largely on the dead weight of the heavy frame to force the tines into the ground, in fact heavy weights were sometimes laid on them to make them face hard work. This was because it was not realized that the pitch or angle of curve of the tine to a great extent controlled the ease with which the tine could enter the ground; in fact that a well-set tine would naturally draw into the soil almost independently of, or at any rate with only a small amount of pressure. Where pressure is depended upon there is necessarily more friction below than where a tine merely draws in, consequently the draught was very heavy The gradual development of the cultivator is interesting as showing the progress and improvement in mechanical methods and construction. Whereas twenty years ago the common cultivator or drag employed in Wiltshire, Hants, and adjoining counties with chalk soils, was made with a heavy wooden frame, with tines set in holes bored through the frame incapable of being adjusted as to width, and with practically no mechanical aid to alter the wheels to adjust the depth of the tines; with no provision to lift the tines without lifting the whole implement; and with tines which were only very slightly curved to face the work: now the modern spring sickle-tine cultivator possesses powers of adjustment quickly and easily manipulated, with curve tines set so as to avoid under friction, requiring but a small weight to force them or draw them into the ground. Cul-

tivators on better lines than the one first described had, however, been available, and had been freely used in many districts, and some had attained much efficiency. As long ago as 1824, Finlayson brought out a curved tine cultivator on three wheels, the front one having an axle mounted on a bell-crank lever, to raise the fore part, while the hind wheels were raised by a rack and pinion. This may be regarded as the first great stride from the old type. Scoular soon improved this by mounting all the wheels on bell cranks, operating them with one lever. The cranked axle was introduced in 1843. Clay and Coleman and Morton made cultivators which were held in high esteem throughout the latter half of the 19th century; Clay's was light, and the shape and pitch of the tines were distinctly good, and the means of adjusting convenient. This type was copied considerably by other manufacturers, and on the whole the cultivation was satisfactory. The introduction of the modern sickle tine by Messrs. Massey Harris in 1893, and in more rigid form by Messrs. Howard at the Leicester show of the Royal Agricultural Society, however, opened up a new era in cultivation, and the advantage of this type very quickly became recognized, and now it may be held that in both heavy and light cultivators all other types are superseded. A comparison between the cultivators exhibited not many years ago at the Royal Agricultural Society of England show and those now exhibited, affords a most striking illustration of the rapidity of the change, and is only equalled by the change in type of haymaking machinery which is now in progress. The work done by the tine with a sickle curve differs widely from that of previous shapes, for instead of merely breaking a line through the soil, this form of tine causes the soil to ride up the curve and to be thoroughly inverted; the liveliness of the work from this motion, and from the vibratory action of the spring tine, gives the land a most effective working, and whether applied as a cleaning operation or in the preparation of the seedbed, the result is far superior to the older methods.

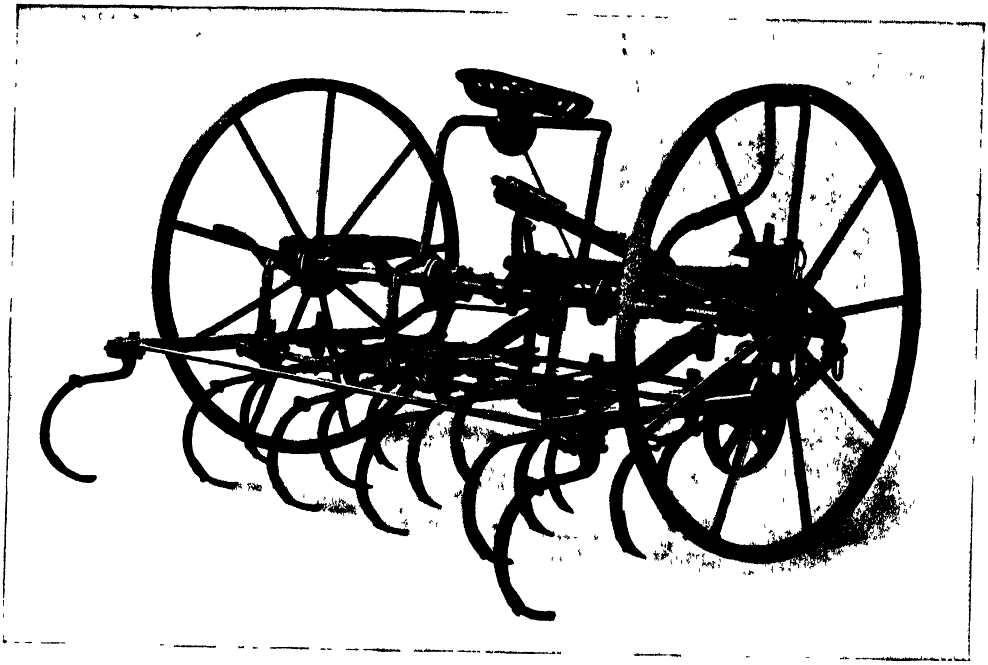


Martin's Cultivator as a Three-furrow Ridger

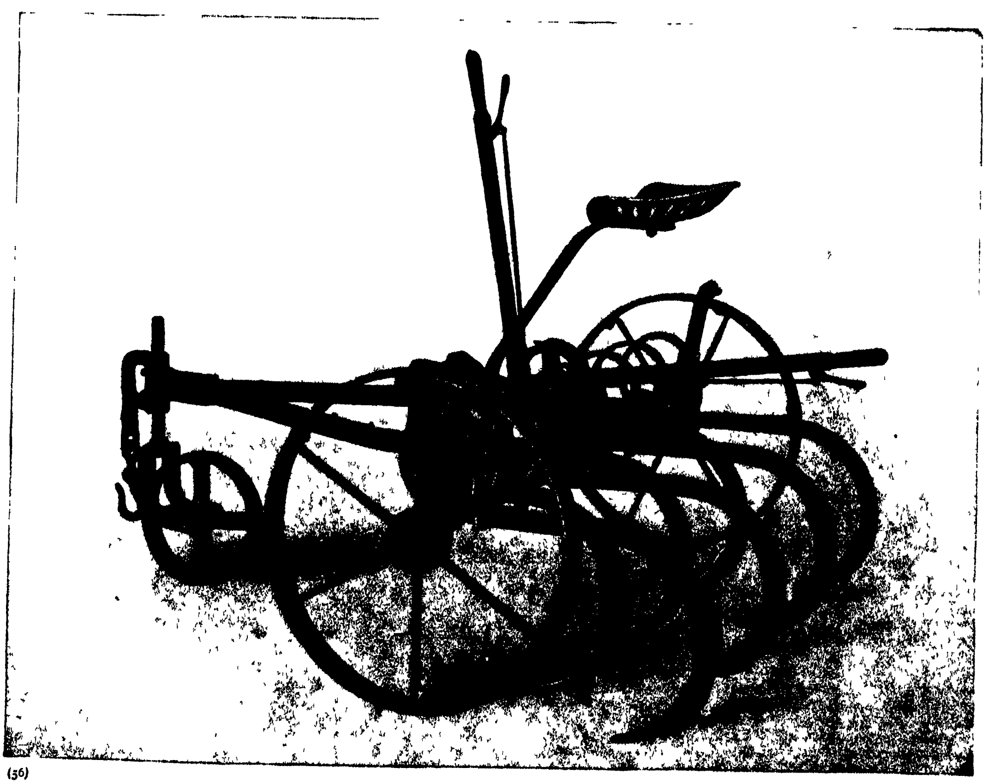
The sickle-tine cultivator may be divided into three types: (1) the rigid, or nearly so, which is suitable for breaking up very hard soil, or for stirring very rough land, though it does good work when land lies in a finer condition; (2) the spring tine, in which a lighter and more vibratory tine is used, and a large number of tines are inserted in a given width; (3) sickle-tine harrows, that is cultivators without wheels, made lighter for finer work. The heaviest cultivators are made with steel tines, giving a certain amount of vibratory action, but the more advanced have a spring attachment to the frame which supplies further vibration and retraction; but the piercing of hard ground is ensured by the spring having a limited yield, so that the tine is brought to rigidity against the frame when this point is reached. A cultivator of this type is convertible into many forms, and with slight alteration of parts, or with additional attachments, may perform many kinds of operations. The points are changeable, and may be used in various widths from plain points to broadshares cutting the whole of the ground; the tines may be altered in position to grub between rows of root crops, beans, &c, and act as horse hoes or plain grubbers; moulding bodies may be attached so as to form three ridgers for potatoes or roots; and a corn box may be added to make an efficient broadcaster: with these attachments a very economical land-working outfit may be secured, securing high efficiency in every section of the work. The lighter forms of wheeled cultivator are generally made in sections, each section being controlled by some form of spring to regulate the pressure on the tines. These cultivators also can be fitted with points of varying width, according to the nature of the work done.

The Norwegian harrow or double rotary harrow is a cultivator of distinct type. Two barrels or drums, one before the other, are suspended from the frame, which is carried on wheels. The barrels act as spindles placed at right angles to the line of draught; sprockets taking the form of slightly curved tines are thickly placed about the barrels, and the barrels are placed so near to one another that, as they rotate, the tines of one barrel pass through the interspaces of the tines of the other. Rotary motion is given to the barrels as the implement is drawn forward, and both a clod-piercing and soil-stirring action is produced; the teeth on the first barrel are naturally making an upward motion as those on the hinder one are coming down, therefore weeds which have been picked up by the one are cleared off by the other. The implement possesses useful features, but the modern cultivators are generally more serviceable. [W. J. M.]

Culture, Bacterial.—To grow bacteria successfully we must, as in the cultivation of higher plants, know something concerning their physiological requirements, especially as to their relations to food, air, and temperature. Moisture, of course, is needed by all. As to *food*,



NICHOLSON'S SPRING STEEL TINE "HERCULES" CULTIVATOR
(Heavy Pattern)



MARTIN'S CULTIVATOR (seven tines)

most races of bacteria require to be supplied with organic matter, the material most commonly used in laboratory cultures being carefully prepared beef tea, to which some peptone and a little common salt are added, and the whole made slightly alkaline with sodium carbonate, as bacteria, as a rule, dislike an acid medium. Most kinds of bacteria will—if other conditions be favourable—grow and multiply in this fluid. But while a liquid medium has its uses, it has also its obvious limitations. Solid media are required in research, and slices of sterilized bread or potatoes were first employed, but a much more convenient 'soil' was introduced by Dr. Koch. He used gelatine with the beef tea, so that when it 'set' it formed a solid, transparent substance admirably fitted for bacterial cultures. The gelatine, in fact, plays the part of pure clay in an ordinary soil, as, while not in any way interfering with the life functions of the living organisms, it holds the necessary nutritive substances for the minute plants to feed upon. If we are growing any particular kind of bacteria requiring a special nutritive ingredient, say for example a lactic-acid former, then it is easy to add the required percentage of milk sugar as a special 'manure' to the soil to secure an abundant crop. If a medium is required that will keep solid at a higher temperature than gelatine (gelatine will melt at 24° C. to 26° C.), then agar-agar is used, the melting-point of which is 98° C. to 99° C.; it is used for the cultivation of blood-heat forms of bacteria.

The cultivation in solid media is conveniently carried out in shallow glass dishes provided with glass lids and known as 'Petre dishes' (see Plate, DAIRY BACTERIOLOGY), or on a slanting surface in test tubes. If our object is to ascertain the number of bacteria present, say in a drop of putrefying liquid, or to isolate for purposes of more detailed study the germs there present, we dilute the drop in so much sterile water as will, when well shaken up, so widely separate the individual germs that only about a score or thereabouts would be present in a drop of the diluted liquid. We then transfer a drop of this to about a half-tubeful of melted gelatine, roll it well between the palms to distribute the germs, and then pour the inoculated jelly out into the Petre dish. Each single separated bacterium will then grow, and ultimately form a little cluster or 'colony' of progeny, which will of course be a pure crop without a single 'weed'. We have now isolated the mixed species, and can subcultivate in liquid or on solid media according to whatever aims or objects we may have in view. Some bacteria can only grow in the absence of air, and special methods of culture must be adopted, which will be explained when dealing with manures. In the cultivation of bacteria we must also keep in mind the temperature most favourable to the species we are attempting to grow. An intestinal germ, for example, demands a higher temperature for its development than a true water or soil bacterium. [D. H.]

Cumberland Pigs.—In the old coaching days Cumberland hams and bacon held a high place in the food purveyors' world. These were manufactured from pigs possessing size, a long carcass covered with a thin skin sparsely covered with fine hair, and well-developed hams. With the aid of a large quantity of dairy offals which could not be otherwise utilized, farmers were enabled to keep the store pigs at a very slight cost until they approached an age of a year at least, when they were put up to fatten slowly, still with a large proportion of skim or other milk, whey, &c., until the resultant carcass was large and fat. The old type of pig has ceased to exist in its purity; the colour is still left, but the style has been changed by Large White boars. [S. S.]

Cumin, an umbelliferous plant (*Cuminum Cymnium*), native of Upper Egypt, the seeds of which are used for flavouring soups and pastry, and also in the manufacture of certain liqueurs. It is an annual about 6 in. high, with narrow leaves and small lilac flowers in umbels. The seeds are elongated, ribbed, and hairy; they are somewhat pungent to the taste, and very aromatic. Sown in the open ground in May they quickly germinate, and by the end of July the plants will be in seed again. They are easy to cultivate. [W. W.]

Cupressus. See CYPRESS.

Curb.—Curb is the name given to an enlargement at the back and lower part of the

Curb

hock joint, caused by sprain of the flexor pedis perforans tendon. Hunters and light-

bred animals are the most frequent subjects of this accident, but no class of horse is wholly exempt. It varies from an enlargement so slight that it can only be discovered by examination from the side, to a swelling similar to that seen in the illustration. It may be caused by jumping or other strain in the well-formed hock, but there is a conformation as well as heredity which leads us to expect it in some animals. More or less lameness, with local heat and some degree of tenderness, characterize the sprain. *Treatment* consists in warm fomentations, hot bandages, an aloetic purge, rest, and a high-heeled shoe, followed by a blister over the swollen region. Although recovery may be expected, curb constitutes unsoundness. [H. L.]

Curd.—Curd is the name given to the insoluble substance which is formed when milk is acted upon by rennet or by acids. The caseinogen of the milk is converted into calcium caseinate in the first case (see CHEESE), while in the second, caseinogen is precipitated by the acid from the calcium caseinogenate of the milk. In either case the calcium phosphate and fat which are kept up by the calcium caseinogenate are precipitated with it.

The rennet curd (calcium caseinate) is used chiefly for cheesemaking, and its mechanical condition is controlled by the acidity of the milk and by the temperature of renneting. If milk is coloured with rennet without the development of acidity a soft curd results; this curd also will not shrink so much as a curd produced from an acid milk. Too much acidity, on the other hand, results in a hard curd, which will shrink to a much greater extent, resulting in a hard acid curd. A rise in temperature hastens the coagulation of the milk up to a certain point. The action is most rapid at 100° F. and ceases at about 130° F. The temperature and degree of acidity used will vary with the kind of cheese which it is desired to make, and also with the nature of the milk, the ash constituents probably exerting a considerable influence. The distribution of the various constituents of the milk when made into whey and curd is given by Richmond as follows:—

	Milk. per cent	Whey per cent	Curd per cent
Water	87·10	80·60	6·50
Fat	3·90	0·30	3·60
Milk sugar	4·75	4·45	·30
Casein	3·00	0·40	2·60
Albumin	0·40	0·40	trace
Ash	0·75	0·60	0·15

The same authority gives the composition of curd and whey as follows:—

	Water. per cent.	Fat. per cent.	Milk sugar. per cent.	Proteins. per cent.	Mineral matter. per cent.
Curd	49·43	27·38	2·04	20·00	1·15
Whey	93·21	0·30	4·99	0·92	0·58

The curd produced by acid (caseinogen) may be prepared in several ways. For cheesemaking it is usual to use the natural lactic acid developed in the cheeses, but with the exception of cream cheeses and a variety called 'Glarner Schabziger', they are of very inferior quality, and are hardly known in this country.

In the preparation of commercial casein from milk it is more usual to take the curd which is obtained with dilute mineral or acetic acids, and it is important to avoid adding excess. The curd can be dissolved in dilute ammonia or in sodium carbonate (care being taken to avoid the solution becoming alkaline), and reprecipitated. If, as is usually the case, separated milk is used, and the fat also extracted with ether, fairly pure caseinogen can be prepared by this process. Many products are made from commercial casein, varying from a kind of ivory to various food products. 'Eucasein' is ammonium caseinogenate, 'Nutrose' and 'Plasmon' are sodium caseinogenates. [J. GO.]

Curd Knife. See DAIRY APPLIANCES.

Curd Mill. See DAIRY APPLIANCES.

Curlew (*Numenius arquata*, L.).—This comparatively large resident species of wading bird (the 'whaup' of Scotland) is about 2 ft. long, and easily recognized by its long, downwardly curved bill, white rump, and plumage streaked with brown and black. During winter it haunts the coast, but breeds on moorlands in April, laying four pear-shaped eggs blotched with brown on olive-green. These are deposited in a slight depression scraped in the ground. The Curlew feeds on insects, slugs, snails, worms, and wild berries, to which small fishes and crustacea may be added when it lives on the coast. It is of no great importance to agriculture, but is entirely beneficial and deserves to be protected. [J. R. A. D.]

Currant.—For the culture of Black Currants see the art. on BLACK CURRANTS. The red and white varieties are treated in the art. on RED CURRANTS.

Currant. — Parasitic Fungi. — Red, White, and Black Currants and other species of Ribes are included here, but the fungi parasitic on Gooseberry are dealt with separately (see GOOSEBERRY).

LEAF AND FRUIT SPOT.—The following common fungi do not as a rule cause much injury, but cases are recorded where they brought about early leaf-fall and thus prevented ripening of the fruit, and also the maturing of the new wood. Anthracnose (*Glœosporium ribis*) is distinguished by circular brownish spots studded with tiny pustules, which give off minute sporules. Leaf Spot (*Septoria ribis*) forms irregular spots with a brown or purplish colour. Rust (*Puccinia ribis*) forms small spots from which teleutospores are given off. Powdery Mildew is due to the same fungi as on Gooseberry; recently the American Mildew has been detected on red currant bushes (see GOOSEBERRY). *Treatment.*—The winter stage of these fungi may be destroyed by collecting and burning dead leaves from spotted bushes. For spraying, potassium sulphide (1 oz. in 2 or 3 gals. of water) is used while the fruit is ripening; Bordeaux mixture is used in autumn and for early spraying before the leaves unfold. Some varieties are more resistant than others, and growers should select these; thus one observer found Red Dutch less injured by anthracnose leaf spot than Red Cherry Currants.

STEM ROT.—The stems and branches may be

attacked by *Nectria* canker (see APPLE), and by other parasites. If pruning is not effective, then the bushes should be destroyed. [W. G. S.]

Currant, Insect Enemies of. — The following are the chief insect enemies of currants, viz.: the Currant Sawfly (see NEMATUS RIBESII); the Currant Moth (see ABRAXAS GROSSULARIATA); the Currant Gall Mite (see ERIOPHYES RIBIS); Currant Borer (see INCURVARIA CAPITELLA); Currant Clearwing (see ÆGERIA TIPULIFORMIS); Currant Aphides (see PHOPALOSIPLUM RIBIS and MYZUS RIBIS).

Currying.—The currycomb is a useful but much-abused implement, which some good authorities would banish altogether from the stable, in favour of more straw wisping and greater exertion on the part of the stableman or strapper. For removing accumulations of scurf and dirt from the skin, the currycomb is a quick and effectual implement, but must be used with care, or the annoyance of its sharp teeth in contact with the shoulder blade, the hip, and other prominences may be the beginning of cribbiting. It may also serve, like other stable tools, to spread mange if employed upon an infected animal. There will be little need of the currycomb where good grooming is the rule, the desquamating cuticle being daily removed by wisping, dandy brushing, and sweating—either by work or well-apportioned exercise. [H. L.]

Cuscuta. See DODDER.

Cutting.—This term is used for a portion of a plant, usually a branch, which is removed and placed in soil under favourable conditions, where it will develop roots from the base and form a separate plant. Theoretically every plant may be reproduced in this way, but in some cases it is difficult to keep the cuttings in health until they have callused and formed roots. In tropical countries quite large branches are used as cuttings. Pieces of the roots and of the leaves of certain plants may also be used as cuttings. [W. W.]

Cyanides. See HYDROCYANIC ACID.

Cyclamen, a distinct genus, related to Primula, remarkable in having a large perennial woody rootstock from which leaves and flowers are developed every year. About a dozen species are known, the most popular being *C. persicum* (*latifolium*), a native of Greece and Syria, and cultivated as a greenhouse plant for at least a hundred years. It is enormously improved in the size and colour of its flowers, and there are few more useful plants in winter than well-grown pot specimens of this Cyclamen. The other species are sufficiently hardy to be grown out-of-doors in this country; indeed one of them, *C. hederæfolium*, is naturalized in some parts of England, in Cornwall for instance, where both it and *C. coum* are not uncommon in the woods, and flower profusely in early spring. [W. W.]

Cydonia, a genus of Rosaceæ which includes the Common Quince (*C. vulgaris*). Other species grown for their flowers are the Japanese Quince (*C. japonica*) and the Chinese Quince (*C. cathayensis*), although these fruit freely under some conditions, and their fruits are sometimes used in making jellies and for flavouring. Grown as a bush or trained against a wall, the Japanese Quince is a most attractive shrub, as it blooms very freely in spring, the flowers being like those of the apple but coloured rich-crimson. There are also varieties with white and pink flowers. *C. Maulei* is a dwarf form which has brick-red flowers and is very free in the production of fruits. These are all easily accommodated in the garden. [W. W.]

Cynara is the botanical name for a genus of the order Compositæ, with all the flowers in the large head tubular. The involucral leaves round the flowers are fleshy, overlapping at the base, and spread out at the point. The cypsela fruit is crowned by a feather pappus. The cultivated species are: Cardoon or Chardon (*Cynara Carduncaulus*), a hardy, spiny-leaved perennial with purple flowers; Garden Artichoke (*Cynara Scolymus*), like the Cardoon, but not so tall. [A. N. M'A.]

Cynips kollari (the Marble Oak-gall).—This well-known gall, found on the oak in Britain, is round, like a marble, at first green then brown. Each gall contains a single central

1 2 3

Oak-galls

1, 2, Galls from *Quercus infectoria* (Aleppo) 3, Transverse section

chamber, in which a white, footless, fleshy maggot lives and matures. The adult gall-fly escapes by eating its way out through a round hole, it is reddish-yellow. So far only the female is known, reproduction being entirely asexual. It was first noticed as abundant in Devonshire. It is now found over most of Britain, and has gradually increased during the last forty years. Various attempts have been made to use these galls for ink-making purposes. It is very injurious to young oaks in nurseries, stunting and deforming their growth, and all such stock should be at once pulled up and burnt. It mostly attacks young stock, but is also found on older trees. The galls often contain the larvæ of other gall flies, which live in them as inquilines called *Synergi*, which form chambers around the Cynips. The Cynips larvæ are attacked by numbers of chalcid parasites, which do not, however, seem to check their increase. Tits peck out the maggots in winter. [F. V. T.]

Cynosurus cristatus.—This is the botanical name of the grass commonly known as Crested Dog's-tail. See CRESTED DOG'S-TAIL

Cyperaceæ, or **Sedges,** is the name for a nat. ord. of monocotyledonous weeds which resemble grasses in many respects. The points which distinguish the vegetative organs of sedges from grasses are: (1) The stems are solid, usually triangular in section; (2) the leaf-sheaths are entire, not split, and not swollen at the point where the sheath joins the stem.

In poor moorland pastures sedges are frequent, and they are most readily distinguished from the associated grasses by noting the arrangement of the leaf-blades; in sedges the leaf-blades spread in three directions, diverging at an angle of 120°, whereas in grasses the leaf-blades spread in two directions, at an angle of 180° [A. N. M'A.]

Cypress (Cupressus) is a genus of the Cupressineæ tribe of the conifers, which consists of evergreen trees and shrubs (the deciduous Marsh Cypress is botanically not a true Cypress). In this tribe the foliage consists of scale-like sessile leaves, sometimes alternating, but usually opposite or in whorls; while (except in the Juniper) the small globular or oblong cones have woody scales. This Cypress tribe is divided into four sub-tribes and six genera: (1) True Cypress (Cupressus), (2) False Cypress (Chamæcyparis), (3) Arborvitæ (Thuja, Biota, and Libocedrus—see ARBORVITÆ), and (4) Juniper (Juniperus—see JUNIPER), among all of which the Common Juniper is the only species indigenous to Britain.

(1) The True Cypress sub-tribe, consisting of the genus Cupressus, has small, scale-like, closely appressed, opposite and mostly imbricate leaves, and comparatively large, globular or oblong, woody cones, with numerous seeds to each scale, that ripen in the second year, when the cone-scales become woody, peltate and angular, then dry and separate, each of the six to ten woody scales having a central projection. The leaves along the branchlets are mere scales overlapping each other, and generally in four rows. This sub-tribe consists of large trees indigenous to Southern Europe, Western Asia, North America, China, and India, where the Cypress is called 'the tree of life' owing to wonderful properties being ascribed to its berries, &c., as a cure for all diseases. They are all resinous trees, but give no turpentine. The two species grown in Britain are the Italian or Common Cypress (*C. sempervirens*) of the Mediterranean and Western Asia, introduced in 1548, and the Large-coned Cypress (*C. macrocarpa*) of Upper California, introduced in 1838. These are characterized by having four-angled and unflattened twigs, on which the flank-leaves are like those on the two faces; but the scale-like green leaves of the former are blunt at the tip, while those of the latter end in a sharp projection. The Italian Cypress is usually of pyramidal and fastigiate growth. Though it attains up to 80 or 90 ft. in height in Southern Europe, it seldom in Britain exceeds 20 to 25 ft. and is essentially bushlike in character, though highly ornamental in small avenues, and especially in churchyards, for which its rather yew-like and sombre appearance makes it very suitable. It grows best on a deep sandy loam, and can be raised from home-grown seed, though the easily obtainable Mediterranean seed is better. During the first winter the seedlings need protection against frost. The Large-coned Cypress is a bigger tree, with bright-green foliage, which is apt to suffer from frost in damp localities, but otherwise can do well in southern England. The two largest specimens reported in 1903 were one with a girth of 10 ft. 3 in. (top broken by a gale; Coollatin, Co. Wicklow, 52 years old), and another 68 ft. high and 9½ ft. in girth (Kent, 49 years). Its timber is soft, pale, and easy to work, but the tree has only an arboricultural interest here. It can be grown from the seed, freely produced, and is of rapid growth at first, especially on dry soil and in a sheltered locality. Both species can also be grown from cuttings, whereby several gardener's varieties have been produced.

(2) The False Cypress sub-tribe, consisting of the genus Chamæcyparis, is represented in Britain by three species—Lawson's Cypress (*C. Lawsoniana*), the Alaska, Sitka, or Nootka Sound Cypress (*C. nutkaensis*), and the Japan or Obtuse-leaved Cypress (*C. obtusa*). Their leaves or needles resemble those of the True Cypress; but those on the upper and the under sides of the twigs are flat, while the flank-leaves are folded together and give the twigs a flattened look resembling the Thuja. The small cones, which ripen in the autumn after flowering, have round angular scales of inverted pyramidal shape, which open wide to scatter the two to five compressed and winged seeds.

(*a*) Lawson's Cypress, one of the handsomest of North Californian trees, was introduced into Britain in 1854, and is one of the most graceful, beautifully foliaged, and hardy trees of its class. It grows quickly and endures side-shade, but though it here produces a compact, close-grained, and somewhat resinous wood, it is hardly of such sylvicultural importance as the other two fine Californian trees, the Douglas Fir and the Sitka Spruce. It does best on dry or merely fresh sandy or loamy soil, but can be grown on most kinds of land not wet or exposed. It produces germinable seed here, but can also be very readily raised from cuttings, by means of which numerous varieties are propagated; and to one of these, which perpetuates the spreading, primary, juniper-like leaves that differ from the scale-like leaves on the ordinary shoots, the generic name of Retinospora has been given. These artificial varieties show great diversity of shape, size, and colour, and include columnar, pyramidal, spherical, flat-topped, and weeping forms, varying from shrubs to tall trees, and greatly variegated in the hue of their foliage. The largest British specimen of Lawson's Cypress reported in 1903 was 57 ft. high and 5 ft. in girth (Kent, 37 years old).

(*b*) The Nootka Sound, Alaska, or Sitka Cypress, indigenous to the north-west coast of America, was introduced into Britain in 1850, and is hardier than the other two species. In many respects it resembles Lawson's Cypress, but is distinguishable from this by its harder, paler green, and less plentiful foliage, its more robust and less graceful habit of growth, by its male catkins being yellow and not crimson, and by its six to eight in place of usually only six cone-scales. It grows well on almost any kind of soil that is not wet, and can thrive fairly well even on poor limestone; and it can be easily raised either from seed or cuttings. The largest specimens reported in 1903 were 45 ft. high by 6 ft. 9 in. in girth (Ross, 30 years), and 47 ft. high by 3 ft. 4 in. in girth (Lincoln, 48 years).

(*c*) The Japan or Obtuse-leaved Cypress, indigenous to the hills of Central Japan, was introduced in 1862. In its general appearance and its habit of growth it resembles the Arbor-vitæ common to the same region, from which, however, it differs in its more spreading branches and their fanlike appearance. Of this, too, numerous artificial varieties are cultivated by cuttings, grafts, and layers. [J. N.]

Cyrtoneura stabulans, a two-winged fly that breeds in decaying potatoes to a considerable extent, when fermenting in a damp place; also on rotten fungi, decaying vegetable and animal matter. They have also been recorded as causing decay in onions with the true onion fly, but this is very doubtful. It occurs indoors in houses and stables. It expands a little more than 7 lines, is of a grey-ash colour, and bristly; the face is silky-white, with a black stripe on the crown; there are four black stripes on the thorax; apex of scutel testaceous; body tessellated with rusty-black; wings with one transverse nervure, the upper cell open, with the lower nervure curved; legs bright-tawny, base of thighs and feet black. [J. C.]

Cysticercus, the term applied to a stage, also known as bladderworm, in the life-history of tapeworms. A cysticercus consists of a small, somewhat tough, pale vesicle, more or less translucent when fresh, and having an opaque, whitish spot on one side. *Cysticercus cellulosæ* occurs in the muscles and viscera of the pig, and is the cause of 'measly pork'. Another common form is *Cysticercus bovis*, met with in the flesh of the ox. A larger form, extremely common in the body cavity of the rabbit, is *Cysticercus pisiformis*, about the size of an ordinary pea. These bladderworms, which occur in various organs other than the alimentary canal, are found as a rule in herbivorous animals, while the adult tapeworms to which they give rise have their abode in the alimentary canal of flesh-eating animals. When, for example, measly pork imperfectly cooked is eaten, the cysticercus on arriving in the intestine everts its head, which till now has been enclosed within the bladder. The head, which is armed with hooks and suckers, attaches to the intestinal wall, and from it an adult tapeworm commences to grow, the bladder being thrown off. The large bladderworm occurring in the brain of the sheep, and causing 'gid' or 'staggers', is a structure similar to a cysticercus, but instead of having a single head it produces a large number. It is known under the name of Cœnurus. See next art. [J. R.]

Cysts, a term applied to bladder or sac-like formations of a pathological nature, irrespective of their immediate cause or significance. Cysts may be of a harmless nature or highly dangerous; they range from tiny vesicles of microscopic dimensions to enormous masses which may fill the whole abdomen. They occur in very diverse situations, *e.g.* in the skin, muscles, mesentery, ovary, brain, &c. The contents of the cyst vary with its type and situation, but they are commonly more or less fluid in character. Many cysts are formed by parasites, and these contain in addition to fluids the parasite or some developmental stage of it. The commonest parasitic cysts are those of tapeworms; they are formed variously from the minute embryo after migration. Examples are the 'bladderworms' of measly pork, the 'Cœnurus' causing 'gid' or 'staggers' in sheep, the 'echinococcus' or hydatid cyst of the dog tapeworm, this stage occurring in various animals and man. Smaller cysts, but occurring in very great numbers, are those of *Trichina spiralis*, a microscopic threadworm found in the flesh of the pig and rat, sometimes also met with in man. Another kind of cyst is that formed by parasitic sporozoa, such for example as the *Sarcocystis tenella* found in the gullet of the sheep. Such a cyst is filled with the spores of this microscopic parasite. The 'coccidium' nodules occurring in the liver of various mammalia are somewhat similar structures. [J. R.]

Cytisus, a genus of Leguminosæ comprising about forty species of shrubs, natives of the western part of the temperate Old World; flowers yellow, white, or purple; leaves one to three foliolate or absent. They are mostly hardy in this country, and a number of them are highly esteemed as decorative spring-flowering plants. Everybody is acquainted with the splendour of *C. scoparius*, the common native Broom, and if it were rarer it would be greatly esteemed as a garden plant. The varieties *Andreanus*, which has reddish-brown wing petals, and *sulphureus* are also very effective. Of the other species the following are best: *C. albus*, White Spanish Broom, 6 to 8 ft.; *C. Ardoinii* and *C. decumbens*, dwarf sorts with yellow flowers, making good rock-garden plants; *C. nigricans*, yellow flowers produced in July; *C. præcox*, cream-coloured flowers, the earliest of all; and *C. purpureus*, 18 in. high. *C. Beanii*, golden-yellow flowers, and *C. kewensis*, cream-coloured flowers, are two excellent hybrids of recent introduction and of trailing habit. These plants are best propagated by cuttings inserted in sandy soil in a cold frame in August. It must be remembered that the taller growing kinds fall off greatly in appearance with age, and that none of them bear transplanting well. Some confusion exists between the genera Cytisus, Laburnum, and Spartium. *S. junceum*, which is known as the Yellow Spanish Broom, is a particularly handsome, tall-growing summer-flowering shrub. *L. Adami*, a graft hybrid between *C. purpureus* and *L. alpinum*, is remarkable in sometimes producing both yellow and purple flowers and Cytisus and Laburnum leaves upon the same plant. The Common Broom attains the dimensions of a small tree in the Mediterranean region, where its wood is employed in cabinetmaking, and a fibre is obtained from the bark. It was this plant, 'Planta genista', that formed the badge of the Plantagenets. [W. W.]

Cytolichus nudus (the Pulmonary Fowl Mite), a minute acarus which inhabits the air sacs and lungs of birds, particularly fowls and pheasants. The mite can just be seen with the naked eye; the female is ·56 mm. long, the male ·45 mm., white and globular in form. They sometimes occur in great masses in the bronchi, and cause obstruction and even death. They

also occur in yellowish nodules in the kidney, liver, and lungs, but are not the cause of them, and have also been found under the skin. Zundel accuses them of causing peritonitis and enteritis. When very abundant, poultry houses should be disinfected with hot limewash, and all diseased birds should be destroyed. [F. V. T.]

D

Dabœcia.—The St. Dabeoc's Heath (*D. polifolia*) is a pretty ericaceous shrub 1 to 2 ft. high, with red, white, or purple flowers, generally much resembling a Heath. It is common in parts of Ireland and south-western Europe, and also grows in the Azores. It forms dense tufts, and flowers from June to September. Suited by a light sandy or peaty soil, this plant is well worthy of a place in gardens where this condition can be afforded. Propagation by cuttings or by seeds. [W. W.]

Dachshund.—The Dachshund, as its name implies (meaning literally badger dog), is a German variety of dog, but it has been for so long a time acclimatized in this country that it may be almost included in the category of national breeds. The fact, moreover, that the breeders in England differ very materially in their ideas and methods from their German friends, has caused the British production to have become a different dog in many respects; and hence another reason for disassociating the two breeds. It is somewhat singular, too, that the Dachshund should be regarded from a totally different standpoint by the breeders of the two countries, those of England regarding it more as a hound, while the Germans claim that it is a terrier and use it as such. Probably the name Dachshund confused some of our countrymen when the dog first appeared in England, and they may have misinterpreted the word *hund* as meaning 'hound', whereas it is merely the Teutonic equivalent for 'dog', which, as *dachs* means 'badger', clearly proves the nature of the work that is expected of the breed in its own country.

Dachshund

Whether the above hypothesis is correct or not, the fact remains that the Dachshund breeders of the two countries have been conducting their operations upon different lines, and with different objects before them, for years, and at present there appears to be no prospect of their ideas becoming reconciled. The main point upon which they are at variance is the shape of the skull, which according to the British breeders' view should be rather narrow and domed, something like that of the Bloodhound but with the characteristics less exaggerated; whilst the object of the German enthusiasts is to secure a flatter and rather wide skull,—in fact, one more of the terrier and less of the hound shape. A difference of opinion, though it is a minor one, also exists as regards the correct colour of the noses of the red specimens of the breed, the Germans preferring a black nose, whilst in this country a yellow one is sought after.

Another point of variance between the Dachshund breeders of the two nations exists in the uses to which the dog is put. Here in England it has practically degenerated into a toy dog, as it is rarely utilized for hunting vermin, being kept more as a companion or for exhibition purposes; but in Germany not only is the breed largely utilized for working vermin, but periodical public trials are held, in the course of which Dachshunds are pitted against fox and badger in artificial earths, in order to test their courage and ability to work underground. It will be seen, therefore, that the breed is endowed with its full share of natural courage, and it is proportionately to be regretted that its undoubted abilities should be permitted to remain undeveloped in sport-loving England, though the fact does not in any way lessen the value of the breed as a working terrier, and as such a very desirable member of a sport-loving country gentleman's establishment. The Dachshund, moreover, is a most companionable dog, and likewise he is a very intelligent one, whilst his curiously contorted front legs preclude the possibility of his travelling fast, and consequently he is essentially qualified to accompany indifferent walkers in their rambles.

So far as his general appearance is concerned the Dachshund somewhat resembles, according to English views, a miniature Bloodhound cut down about the legs, the chief point of difference being that the eyes of the former do not dis-

play the red haw or inner membrane, neither are they so sunken in the head, whilst the heavy wrinkling of the Bloodhound's forehead and his deep flews are not characteristic of the German breed. Still, so far as the shape of the skull goes, there are many points of resemblance between the two, for that of the Dachshund is high, conical, and narrow, the muzzle is long, and the teeth unusually large and regular,—in fact, just of the character that would enable their possessor to punish his quarry very severely. The eyes are of fair size, not prominently set, and are usually of a darker colour in the black-and-tan specimens of the breed than they are in the case of the reds and livers. The ears should be long and pendulous like those of the Bloodhound, according to British ideas, but those of the German type are shorter, wider, and are set on higher up. The difference in the colour of the nose has already been referred to; but a light nose upon a black-and-tan dog is regarded in both countries as a fault, as it is here when associated with a red-coloured jacket, though in Germany the latter combination is regarded as the correct thing. The neck, which is inclined to be long, displays some signs of a dewlap, the shoulders being somewhat short, and then comes the peculiar formation of chest and front limbs which is so characteristic of the breed. The chest is very deep indeed, and appears to project between the fore legs, which are most curiously twisted out at the elbows, in at the knees, and out again at the feet, the latter being large and splayed. They are likewise extremely heavy in bone for the size of the dog, and carry a good deal of muscle; whilst the body is abnormally long, nicely rounded at the ribs, inclined to be tucked up at the loins, and rather higher above them than at the shoulder. The hind legs are rather straight at the hocks, and the tail is long, tapering, and carried gaily but not over the back. Red, black-and-tan, and liver-and-tan are the most common colours; but there are also blue dappled, and black white-and-tan varieties, though these are less frequently met with. The weight of this breed varies from about 20 to 24 lb. [v. s.]

Dactylis. See COCKSFOOT.

Daddy-Long-Legs. See TIPULA.

Daffodil. See NARCISSUS.

Dahlia, a Mexican genus of Compositæ, comprising nine species of tender perennial herbs with tuberous roots. First introduced to Europe in 1789, the original species being probably *D. variabilis*. Great improvements were quickly effected in the form, size, and colour of the flowers, and Dahlias have been popular in this country for nearly a century. Of recent years they have been particularly noticeably improved; there are now a dozen or more distinct types, comprising the Show, Fancy, Single, Pompon, Cactus, Anemone-flowered, Pæony-flowered, and others, and Dahlias were never more widely and enthusiastically cultivated than is the case today. Improved methods of cultivation are partly responsible for this; it was usual to plant the roots direct from the store in late spring, but much better results are obtained by the system of inducing the roots to send up shoots by placing them in artificial heat earlier in the year, and by rooting and growing on the cuttings thus obtained. As they are rapid in growth, and can be depended upon to flower profusely until checked by autumnal frosts, Dahlias are suitable for massing in borders or furnishing large beds, each preferably made up of a single variety, but as they are not exacting in their requirements they are of almost unique value in the humblest garden also. They are best suited by an open situation, with deeply worked, well-drained, and highly enriched soil. It is not safe to plant them out until the first week in June. As soon as the foliage has been injured by frosts it should be cut away, and the roots lifted, labelled, and stored in a dry frostproof place. To obtain an extra fine display, these plants must be abundantly watered in the absence of copious rains, and the growths judiciously thinned. Dahlias are easily raised from seeds. There are several hundred varieties, and these are being constantly added to. [w. w.]

Dairies, Cow Sheds and Milk Shops Orders.—The first legislative provision with regard to the inspection of cattle sheds, byres, &c., was that made by the Cattle Sheds (Scotland) Act of 1866. By this Act—which applies only to Scotland—provision was made for the inspection and licensing of cattle sheds, cow houses, and byres within burghs and populous places in Scotland, and power was given to the magistrates to require the owner or occupier of such premises to make such sanitary improvements in the same as they should direct, within one month of the date of the notice, under the penalties referred to in the Act. This Act is not affected by the later Orders referred to below. Thereafter no legislation with regard to cow sheds or milk shops took place until the passing of the Contagious Diseases Animals Act of 1878. By this Act, power was conferred on the Privy Council (subsequently transferred to the Board of Agriculture) from time to time to make such Orders as they might think fit, for the following purposes or any of them, viz.:—

1. For the registration with the local authority of all persons carrying on the trade of cowkeepers, dairymen, or purveyors of milk.
2. For the inspection of cattle in dairies, and for prescribing and regulating the lighting, ventilation, cleansing, drainage, and water supply of dairies and cow sheds in the occupation of persons following the trade of cowkeepers or dairymen.
3. For securing the cleanliness of milk stores, milk shops, and of milk vessels used for containing milk for sale by such persons.
4. For prescribing precautions to be taken for protecting milk against infection or contamination.
5. For authorizing a local authority to make regulations for the purposes aforesaid or any of them, subject to such conditions, if any, as the Central Authority prescribe.

In virtue of the power thus conferred, the Central Authority have issued orders, of which the principal is that of 1885. By this Order, as modified by subsequent Orders, it was, *inter alia*, provided—

1. That it should not be lawful for anyone to

carry on the trade of cowkeeper, dairyman, or purveyor of milk, unless he was duly registered in a register which every local authority must keep. This, however, does not refer to persons carrying on such trade merely for the purpose of making and selling butter or cheese, and who do not purvey milk. Further, a person who sells milk of his own cows in small quantities to his neighbours or workmen does not require to be registered by reason only of such selling.

2. Such registration shall not be deemed to authorize anyone to occupy as a dairy or cow shed any particular building, or in any way preclude any proceedings being taken against them for non-compliance with, or infringement of any of the provisions of the Orders.

3. Public notice must be given by local authority that registration is required, and also as to the mode of registration.

This Order further makes provision for the construction and water supply of new dairies and cow sheds, and deals with the lighting, ventilation, and cleansing, as well as the water supply of the premises. The Order further makes it unlawful for anyone to occupy any premises as a dairy or cow shed, unless the lighting and ventilation, including air space and the drainage and water supply, are sufficient—(*a*) for the health and good condition of the cattle therein; (*b*) for the cleanliness of milk vessels; and (*c*) for the protection of the milk against infection and contamination.

It is unlawful for anyone following the trade of cowkeeper or dairyman or purveyor of milk, or for the occupier of a milk shop, to allow anyone suffering from a dangerous infectious disorder, or who has recently been in contact with anyone so suffering, to milk cows or handle vessels used for containing milk for sale, or to take part in any way in the production, distribution, or storage of milk. The same prohibition, of course, applies to the keeper himself.

It is also declared unlawful—

(*a*) To permit any water closet, earth closet, privy, cesspool, or urinal to be within, communicate directly with, or ventilate into, any dairy or any room used as a milk store or milk shop.

(*b*) To use a milk store or milk shop as a sleeping apartment, or for any purpose incompatible with the proper preservation of the cleanliness of the milk store or milk shop, and of the milk vessels and milk therein, or in any manner likely to cause contamination of the milk therein.

(*c*) To keep any swine in any cow shed or other building used for keeping cows, or in any milk store or other place used for keeping milk for sale.

Power is given to the local authority from time to time to make regulations for the following purposes or any of them:—

(*a*) For the inspection of cattle in dairies.

(*b*) For prescribing and regulating the lighting, ventilation, cleansing, drainage, and water supply of dairies and cow sheds in the occupation of persons following the trade of cowkeepers or dairymen.

(*c*) For securing the cleanliness of milk stores, milk shops, and of milk vessels used for containing milk for sale by such persons.

(*d*) For prescribing precautions to be taken by purveyors of milk and persons selling milk by retail, against infection or contamination.

Following on the powers given them by this Order, local authorities in the various districts have from time to time issued regulations dealing with the construction of dairies and cow sheds, the requirements of which are too various to be dealt with here.

If at any time disease (including tuberculous disease of the udder) exists among the cattle in a dairy or cow shed, the milk of a diseased cow therein—

(*a*) shall not be mixed with other milk;

(*b*) shall not be sold or used for human food; and

(*c*) shall not be sold or used for food of swine or other animals, unless and until it has been boiled. See also under MILK, PUBLIC HEALTH. [D. B.]

Dairy Appliances.—Under this heading might be included all dairying appliances, from the small tin pan in which the milk is delivered to the consumer, to the most complicated machinery used in the milk factory. The more important dairying appliances, however, are treated under separate articles, and the less important require only a brief description. A large variety of wooden, tinned, and enamelled vessels is used in the different branches of dairying, but these are simply ordinary vessels used for special purposes, and, in some cases, modified to meet special requirements.

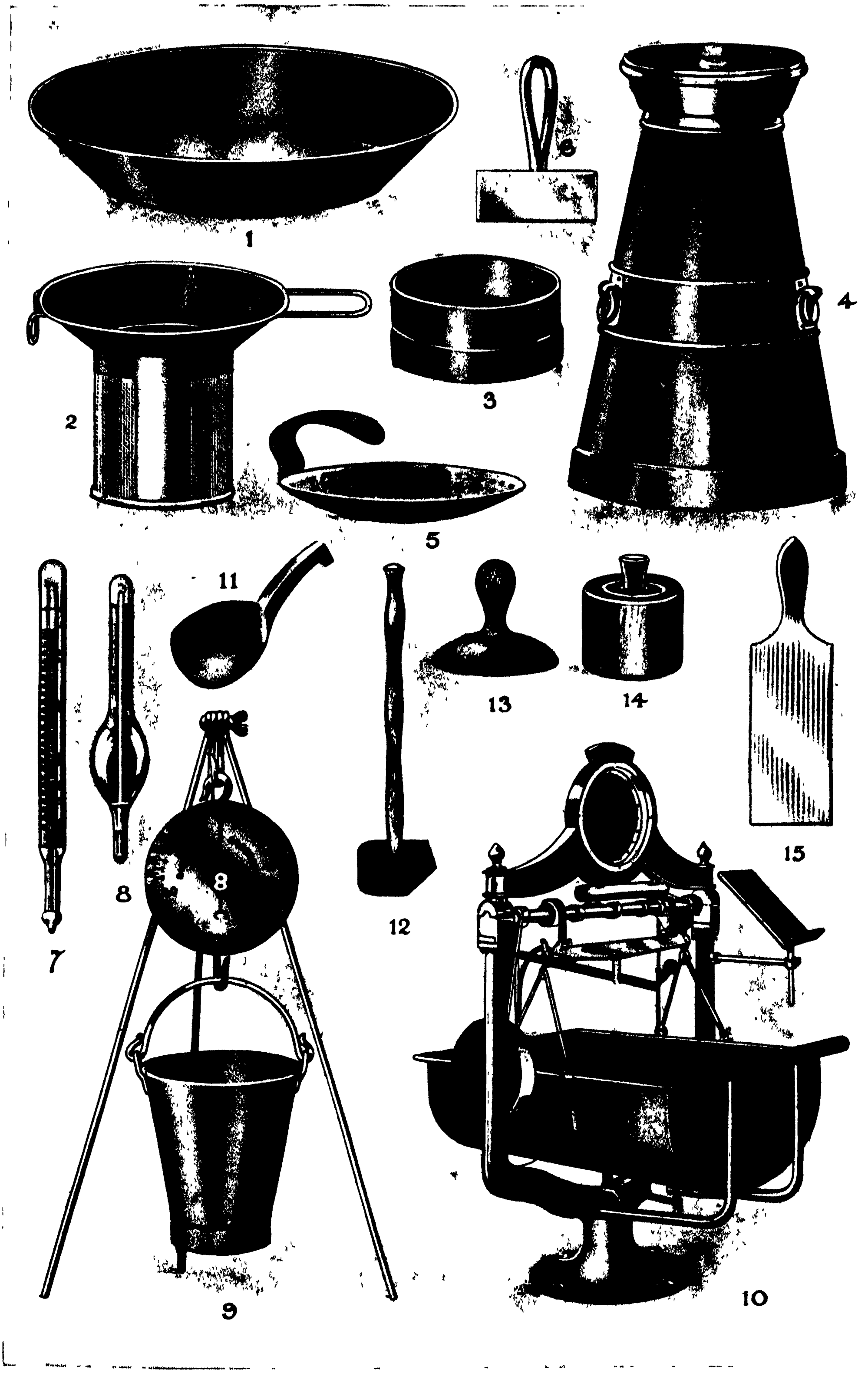
Dairying utensils, properly so called, fall naturally into three groups: those used (*a*) where the milk is sold sweet, (*b*) where butter is made, and (*c*) where cheese is made. So far as possible this arrangement will be adhered to in this article, though it is obvious that certain utensils, such as the milking pail, the sieve, and the thermometer, belong to no particular group but are common to all.

FOR THE SALE OF WHOLE MILK.—*Milking Pail (or Luggy).*—Originally the pail was made of oaken staves bound together by iron hoops. In most cases the diameter at the mouth was a little greater than at the bottom, and one of the staves was continued to form a strong upright handle. Tinned metal is the material now used, and a greater variety of shape has been introduced, though for utility none is superior to the original form. The luggy holds from 2½ to 3 gal.

Milk Plate, Shallow Pan, or Boyne.—The best quality of milk plates are made of blocked tin or enamelled metal. The illustration in Plate I (fig. 1) gives a good idea of an ordinary milk plate, and a common capacity is about 4 gal. As the milk layer is never more than 6 in. deep, the milk keeps well and the cream rises rapidly. These are extensively used where hand-skimming is practised.

Milk Sieve or Strainer.—A very large variety of sieves or strainers is on the market, but the essentials are the same in every case. It consists of a tin frame of a suitable shape, into which is fixed a fine wire gauze. The best form has the gauze or sieve set in the sides instead of the bottom. The sediment is thus trapped in the bottom of the strainer, and is less liable to be washed through by the inflow-

DAIRY APPLIANCES—I



ing milk. A fine muslin cloth should be used with the sieve, or better still, specially prepared cotton wool. Hair sieves fitted into a wooden frame are also in common use. (See Plate I, figs. 2, 3.)

Milk Butts.—These are extensively used in the south-west of Scotland for the conveyance of milk by rail. They are made of strong oaken staves well bound together by iron hoops, and fitted with two iron handles for ease in handling. In shape they are cylindrical, or with a slight taper towards the top, which is flat. In the top is a circular hole about 4 in. in diameter which is stoppered by a cork, and which is the only orifice. They are difficult to clean properly, and are objectionable in every way. The usual capacity is from 4 to 8 gal.

Railway Churns or Cans.—Many forms have been put on the market, but the best is that made of strong tinned steel, having a malleable iron neck (also tinned), which is better able to withstand the tear and wear of the railway journeys, and fitted with a comparatively large but very close-fitting lid, which can be locked. These are practically seamless, easily cleaned, and very durable. Those most commonly used have a capacity of 6 to 18 gal. The illustration in Plate I (fig. 4) gives a good idea of their general appearance.

Milk Skimmer, a slightly concave disk of tin fitted with a handle and used for hand-skimming milk. In some cases the skimmer is perforated to allow the thinner skim milk to run through. (See Plate I, fig. 5.)

Squee-gee, a flexible sheet of indiarubber fitted into a handle and used for cleaning the cream from the sides of milk vessels, &c. (see Plate I, fig. 6).

Milk Balance, a spring balance fitted with a dial, which registers in imperial pints as well as in pounds and ounces. Convenient for use where milk records are kept. (See Plate I, fig. 9.)

Dairy Thermometers.—See general article on THERMOMETER. The best forms of dairy thermometers are those made of glass, and weighted so as to float vertically in the milk. They are easily read, while the entire absence of metal renders them easily cleaned. (See Plate I, figs. 7, 8.)

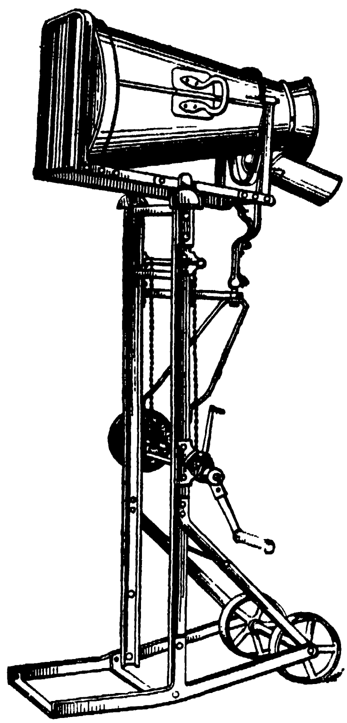
Measuring Pan, a pan with a graduated scale which registers the quantity in pints. They can be had stamped by the Inland Revenue.

Milk-setting Troughs, glazed earthenware troughs about 5 or 6 in. in depth. The bottom slopes gently to a point where there is a hole fitted with a wooden plug. By withdrawing the plug, the milk can be run out.

Milk-weighing Machine, special weighing machines used in factories where large quantities of milk are being manipulated. They are made both of the steelyard and spring-balance type. The milk is run into a large cradle swinging on knife edges, which is fitted with a specially large outlet to admit of its being quickly emptied. (See Plate I, fig. 10.)

Milk Elevator, a mechanical elevator used in factories to facilitate the handling and emptying of the large railway churns into the cradle of the weighing machine.

FOR THE MANUFACTURE OF BUTTER.—*Creamers.*—Where cream is churned, the first step in the process is its separation, and various utensils and appliances are used to effect this. The most important of these is the *Centrifugal Cream Separator*, described in a separate article. Where the cream is allowed to separate naturally by gravity, two types of vessels are used—shallow and deep—and the methods are known as the shallow-setting system and the deep-setting system. The most important vessels in the former case are the *milk plates* already described, but the *Jersey Creamer* requires some notice. It consists essentially of a shallow, jack-



Milk Elevator (Dairy Supply Co., Ltd.).

eted vessel fitted with a roof-shaped lid. When the cream has risen, the skim milk is drawn off from underneath it. It is a well-known fact that cream rises best when the milk is cooling rapidly, and the jacket on this creamer admits of the milk being heated to a fairly high temperature by means of hot water and then rapidly cooled down by means of cold. A thorough and complete separation is thus effected.

The *Deep-setting Method* was never practised to any extent in Britain, and, since the advent of the separator, has fallen into disuse everywhere. It was about 1863 that Gustav Swartz, a Swede, suggested the use of deep vessels cooled externally by means of ice. The Cooley method is a modification of the Swartz, but the two forms are essentially the same. They are vessels about 24 in. deep. (See illustration to art. DEEP-SETTING OF MILK.)

Loppering Crock and Barrels.—The former is

a glazed earthenware vessel, while the latter is made of well-seasoned oak. Both are used for ripening milk or cream.

Churns.—See separate article.

Butter Workers.—Numerous kinds of butter workers are used, but the principle is the same in every case. The essentials are a table, upon which the butter is placed, and a fluted roller to compress the butter and expel the moisture. With the hand butter worker, the roller is pushed along the table and made to revolve at the same time. If the butter worker is driven by power, the table is circular and revolves under the roller (the latter turning on its own axis). The illustrations in Vol. III, pp. 44, 50, and 51, give a good idea of the two types.

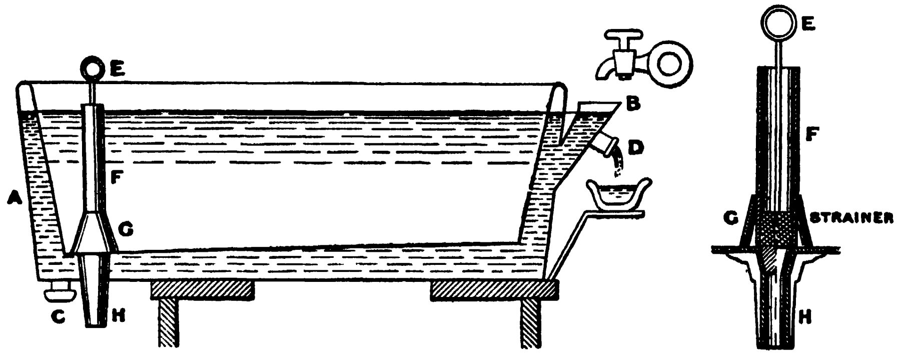
Butter Board, a rectangular-shaped board about 2 ft. × 15 in., upon which the butter is blocked or otherwise prepared for the market. Good yellow pine is the most suitable wood to use for this purpose.

Butter Scoop, a large spoonlike wooden scoop for lifting the granular butter out of the churn. It is usually perforated to allow the water to drain off. A convex wooden disk used in working butter is also called a scoop. (See Plate I, fig. 11.)

Butter Plate, a shallow rectangular plate of glazed white earthenware used for holding butter prints, rolls, or bricks.

Scotch Hands.—These are used for forming the butter into bricks and otherwise manipulating it. The best quality is made from well-seasoned sycamore, and has one face ribbed or finely fluted. The various patterns printed on butter bricks are made with the sharp edge of the Scotch hands. (See Plate I, fig. 15.)

Butter Print.—This has a flat circular face and a handle, and is usually turned from a solid piece of wood. On the flat face a pattern is cut out, and on this the butter is printed, so that when the butter print is removed the pattern stands out on it in relief. (See Plate I, fig. 13.)



Section of Jersey Creamer (with lid removed), and enlarged Section of Plug

A, Double-cased Vessel B, Water Inlet. C, Water Outlet. D, Water Overflow. E, Plug, fitting into pipe F, which is fitted at the bottom with a strainer of fine wire gauze, protected when in use by the ring G (which is removable). Pipe F rests within the fixed pipe H, through which the skim milk is drawn off

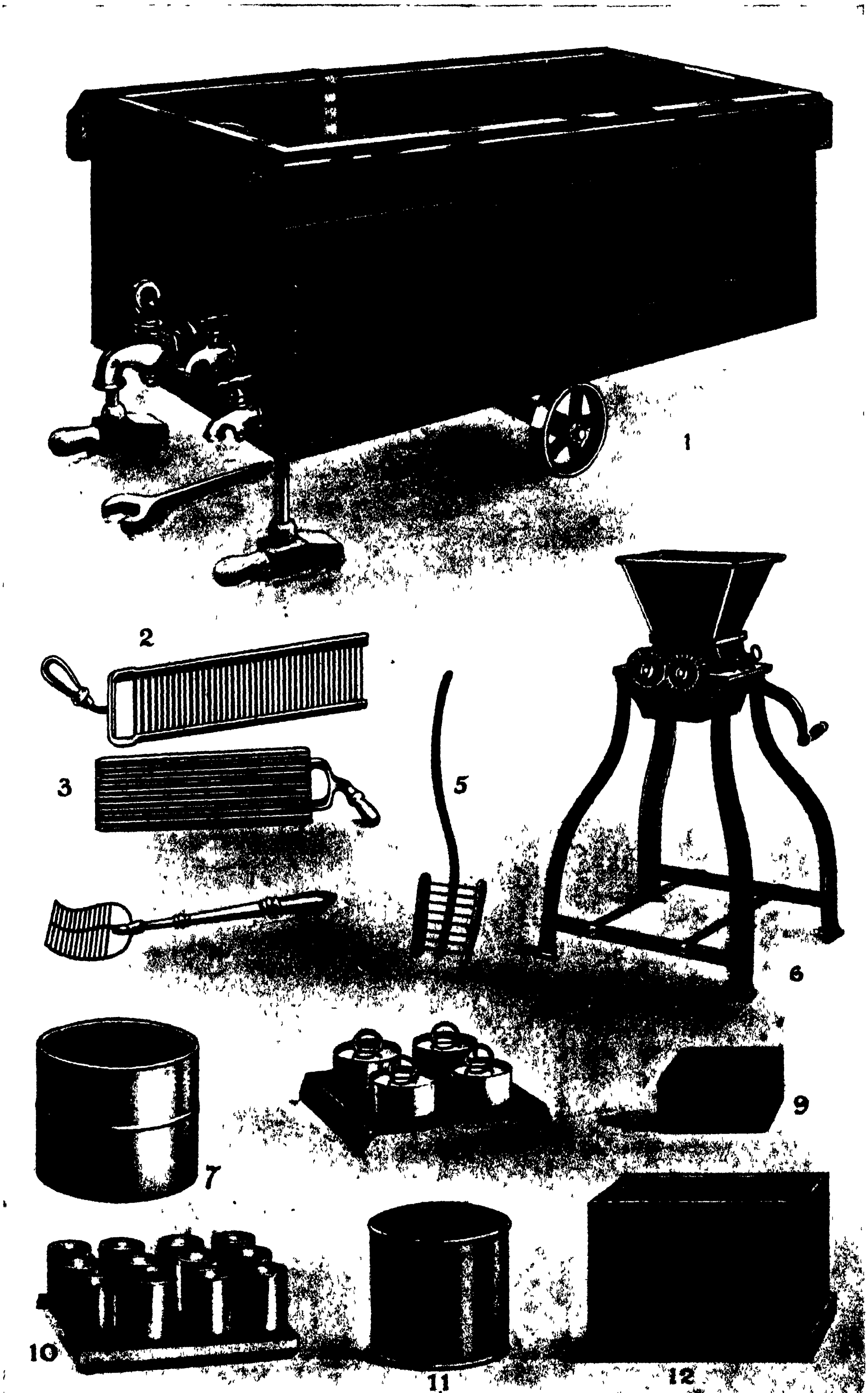
Block Prints or Butter Moulds.—This is a butter print fitted into a suitable mould. The handle of the print passes through a hole in the bottom of the mould. When used, the print is allowed to drop into the mould, and the mould filled with butter; then by pushing up the handle a completed print is forced out. (See Plate I, fig. 14.) An elaborate butter-printing apparatus is used in factories.

Butter Beater, a wooden beater used for compacting salted butter when packing it for the market. (See Plate I, fig. 12.)

Coolers, refrigerators, pasteurizers, sterilizers, &c., are treated under separate articles.

For the Manufacture of Cheese.—*Cheese Vat.*—This utensil, in which some of the most important processes in cheesemaking are carried out, has undergone many modifications. Originally it consisted of a wooden tub. This was superseded by a tin cylindrical vessel called a 'milk heater', which in turn has given place to the modern jacketed vat, which allows steam or water to be used in heating the milk or whey. The best type of vat consists of an outer rectangular vessel or jacket of strong sheet iron, into which is fitted the vat proper, made of well-tinned metal. The vat is a little smaller than the jacket, and thus a clear space is left between them for water. At the back of the jacket is a chute by which the water is added, and also a steam-pipe connection, while at the front are two spigots, one being placed high to act as an overflow and allow water to circulate without the jacket becoming empty. A large spigot for running off the milk or whey is screwed through the jacket into the vat, or inner vessel, a special sieve being used to prevent loss of the curd. The whole is mounted on two small wheels placed a little towards the back, and is further supported on short legs in front and behind. To facilitate emptying, the front can be lowered a little. The vat can be used as a cooler as well as a heater. (See Plate II, fig. 1.)

Curd Knives.—Two curd knives constitute a set, one with vertical blades and one horizontal blades. The blades are composed of thin strips of tinned steel, soldered together as shown in the figure. The knife with the vertical blades is used first, as it is less liable to damage the coagulum during the process of cutting and so cause a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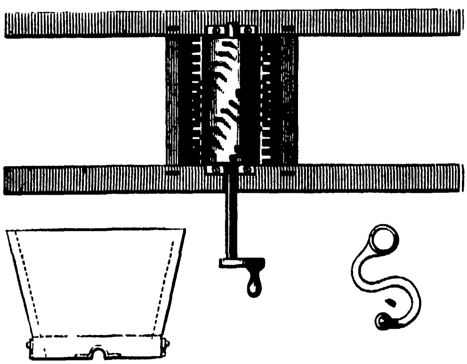
loss of fat. The present form of knives is of comparatively recent introduction. Originally the instrument used for breaking down the coagulum was termed a curd breaker, and a variety of forms were used. One of the most common is shown in Plate II, fig. 4.

Curd Rake.—As soon as the coagulum or curd has been cut and the scalding process begun, it is necessary to keep the pieces of curd in continual movement in the whey. A curd rake is used for this purpose. The form most commonly used at the present day is shown in Plate II, fig. 5.

Curd Rack and Cooler.—This consists essentially of two parts, the cooler and the rack, the rack being merely a series of thin strips of wood fastened together, and of a suitable size to fit nicely into the bottom of the cooler. When in use, the rack is placed in position in the cooler and covered with a cloth; the curd from the



Curd Mill and Hopper

vat is then transferred to it and stirred, when the superfluous whey drains easily away. The cooler is rectangular in shape and about 8 in. in depth, and is made of tinned metal or wood set on a frame of convenient height. It is fitted with a chute, which allows hot water to be run under the rack if the temperature of the curd requires to be raised. During the later stages of the process the rack is removed and the curd spread in the bottom of the cooler. Though called a 'cooler' in common parlance, it is used either as a cooler or a heater.

Curd Pail.—A pail specially made for transferring the curd from the vat to the rack.

Curd Mill.—This is used for breaking down the tough matted curd preparatory to salting. The essential parts are one or occasionally two spiked rollers working against a metal breast or grating. The revolving spikes pass through the openings in the grating, tearing the curd into equal-sized pieces. The curd is fed into a hopper, and, when milled, falls into a dish placed underneath. The whole is fixed on a strong cast-iron frame. (See Plate II, fig. 6, and diagram on this page.)

Chesset or Hoop, the name given to the wooden moulds in which hard-pressed cheese are pressed. There are two general forms, flat and deep. Strong oaken staves and hoops are necessary, as they are subjected to great pressure. The bottom of the chesset is perforated to allow the whey to pass away, and it is fitted with a close-fitting lid. Chessets made of strong tinned metal are now commonly used in the cheese factory.

Cheese Press, a strong metal press used for pressing and moulding the curd in the chesset. There are many different forms on the market, but in nearly every case the pressure is got by a system of double levers. The chesset containing the curd is placed on the press platform, and the pressure disk, which is connected to the levers by a strong screw, is screwed down until the pressure on the lid of the chesset balances the weights applied to the lever. A large Cheddar cheese requires a pressure of about 2 tons. A press capable of pressing a large number of cheeses at the same time is now used in the modern cheese factory. It consists of a long horizontal cradle, made of strong angle iron, for holding the chessets. The chessets are laid on their sides, and the pressure is applied as before by means of a pressure disc actuated by a screw and acted on by a powerful lever.

Cheese Moulds.—Each kind of soft cheeses has its own special form of mould. A few of these are shown in Plate II, figs. 7–12.

Turning Stool, a strong wooden stool used when cheeses are being turned out of the chessets.

See also arts. ACIDIMETER, PASTEURIZING PLANT, REFRIGERATING MACHINERY, MILK TESTING. [J. GI.]

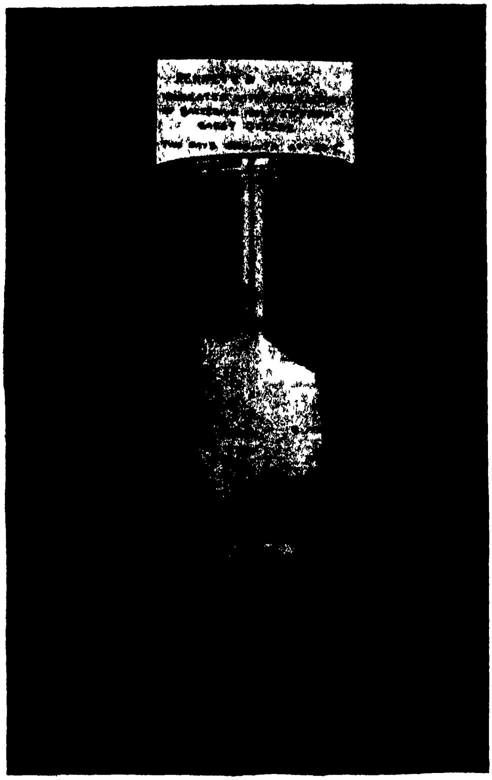
Dairy Bacteriology.—The souring of milk is a common phenomenon. At first sweet and liquid, the milk gradually develops an acid, loses its fluidity, and becomes semi-solid. The acid is 'lactic acid', and arises from the fermentation of the lactose or milk sugar. The fermentation is due to the vital activity of certain forms of bacteria that use lactose as a food and generate lactic acid as a waste product. These lactic-acid-forming bacteria, with others of a different nature, find their way into the milk partly during but principally after its withdrawal from the udder. The extent and character of the bacterial contamination depend, of course, upon the amount of care that is taken to ensure cleanliness during the process of milking, and the subsequent handling of the milk. It should be understood, however, that milk as secreted by a healthy cow is sterile, and that any bacteria subsequently found in it are of the nature of contaminations. If milk be drawn under proper precautions into a sterile flask, and kept free from dusty air by plugging the mouth of the flask with sterile cotton wool, it will remain sweet even if kept for months. Or if ordinary fresh milk be sterilized by heat and kept free from dusty air, it too will retain its sweetness for any length of time. But if the cotton-wool plug be removed, and the milk exposed to the influence of unfiltered air, souring is sure to follow. This is due to the action of bacteria that get carried into the milk through the agency of minute particles of dust. These floating motes act as 'rafts' to convey the very much smaller vital particles to all air-exposed surfaces. Of course bacteria of many different

kinds will be so carried, but whether any particular kind will grow and multiply in the milk depends upon whether that fluid supplies the right kind of food, and also whether the conditions for the time are favourable for their development. Now we know that before any food substance can be absorbed by a living cell it must be in a soluble condition, and if it is not naturally soluble in water it must be made so through the agency of a suitable enzyme, or in other words it must be digested. Now in the case of milk the lactose is already in solution, while the casein and fat are in suspension, hence those bacteria that use sugar of milk as a nutrient find a ready available food immediately they settle down in that fluid. If the temperature also favours them, growth and multiplication begin at once, so that in a comparatively brief time the lactic bacterial population increases amazingly, and as the numbers rise the sweetness decreases and the acidity increases in direct proportion. During the period of lactic fermentation all other bacterial growth is suppressed, just as a thickly seeded field of rapidly growing corn is relatively free of weeds. Moreover, acidity in a medium is disliked by bacteria as a class, so that the sourness of the milk acts as a preservative and keeps in check the growth of putrefactive or other undesirable germs that may be present. So favourable is the composition of the milk to the growth and development of lactic bacteria, and so effectively does the resulting acid behave as a preservative, that it is easy to build up a practically pure culture by repeated sub-cultivations, as will be referred to later on (see STARTER). Another point to be noted is that it would appear that the 'best' lactic bacteria thrive well under anaërobic conditions, that is to say in the absence of air, and this peculiarity of course enables them to grow and multiply throughout a large volume of milk, so that if the germs are evenly distributed in the first instance the milk will sour and thicken uniformly. This is a character of much importance in the ripening of cream for buttermaking. These lactic germs may be easily isolated and systematically studied in detail by methods familiar to bacteriologists (see CULTURE, BACTERIAL). By preparing a gelatine or agar-agar medium, to which a certain percentage of lactose is added to provide the necessary food, and stained blue by the addition of a litmus solution to enable us to detect the presence of acid, we have a convenient 'soil' for the cultivation of these germs. If the fraction of a drop of souring milk (obtained by diluting a drop in sterile water and only using a little of the diluted fluid) be shaken up with a half test-tubeful of the melted litmus-lactose-agar, and poured out in a sterile Petre-dish and then set aside to 'incubate' at summer temperature, the scattered lactic bacteria will grow and multiply in the depths of the solid medium, and in a few days each will form a very tiny colony of offspring as a resulting 'crop'. These colonies can be easily recognized by the tiny specks of red, due to the resulting acid altering the colour of the blue litmus. By means of a sterile platinum needle, one of the acid-forming colonies can be transferred to a flask of sterile milk, and in this way we can with certainty obtain a pure culture of the bacterium. In the manufacture of butter and of cheese, lactic acid plays an important part, and the quality of the product largely depends upon a clean and proper fermentation of the milk or cream, as otherwise no amount of manual skill can counteract the evil effects of bad bacterial contaminations and disturbed lactic fermentation. If the milk is obtained from a healthy herd, and all precautions taken to keep it clean, then it, or the cream separated from it, will ripen properly and naturally, and a well-flavoured and good-keeping product will be the result. On the other hand, if the milk is subjected to dust or dirt contaminations, objectionable bacteria are introduced that are likely sooner or later to give rise to trouble in the milk or its products. These troublesome bacteria belong commonly to the putrefactive group, and are particularly harmful in milk intended for buttermaking. Under favouring conditions these bacteria attack the casein present in the butter and putrefy it. As the bacteria so acting are of the anaërobic group, and as the casein is of a nitrogenous nature, the fermentative products are often particularly offensive. The keeping quality of the butter depends therefore upon three conditions operating simultaneously: (*a*) the presence of putrefying or other objectionable organisms, (*b*) a complex nitrogenous substance to be decomposed, and (*c*) favouring external conditions as to temperature. The non-presence of any one of these conditions will save the butter from undergoing undesirable changes. Milk may also contain bacteria that so decompose the milk sugar as to form gas, and often in great abundance. Such organisms are especially objectionable in milk intended for cheesemaking. They are the cause of the 'gassy' curd that is so troublesome in some dairies and cheese factories. The curd becomes puffy and light, rises and floats on the top of the whey, and thus becomes unfit for cheesemaking.

Oïdium lactis is a very common milk organism. It is one of the lower forms of thread fungi, and almost invariably forms a dense mat of growth on old milk allowed to stand undisturbed for some time. It multiplies by threads, breaking up into a multitude of short joints which act as spores. It is supposed to be associated with the rancidity of butters kept exposed to air.

Yeasts and the spores of moulds are also common contaminations in milk, but as a rule these organisms appear to have little influence upon milk or its products. There is one kind of yeast that is the cause of considerable trouble in the condensed-milk industry. It is anaërobic, and can live in the thick sugar-preserved milk. It cannot attack lactose, but can the cane sugar used in the manufacture of the condensed article. This sugar it ferments with formation of gas, and as the latter collects its pressure bulges out the ends of the tins—a condition known to the trade as 'blown' milk.

Two of the commonest moulds belong to the genus Mucor or dung moulds, and to Penicillium or green moulds. Penicillium often causes annoyance in the case of butter tubs and other



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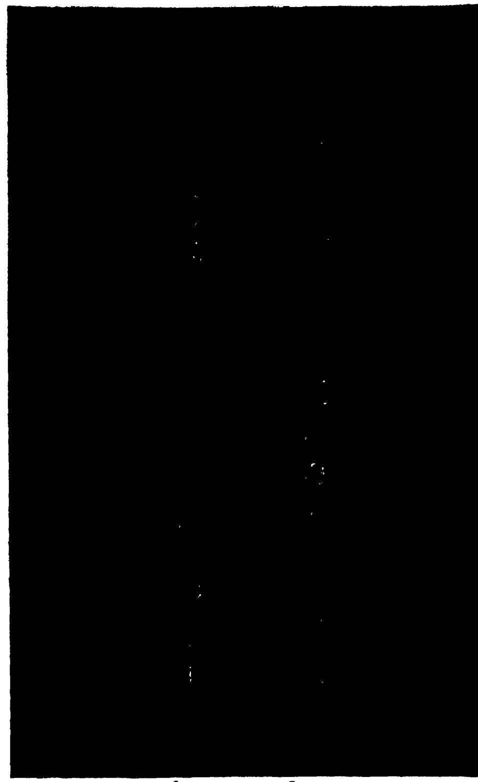

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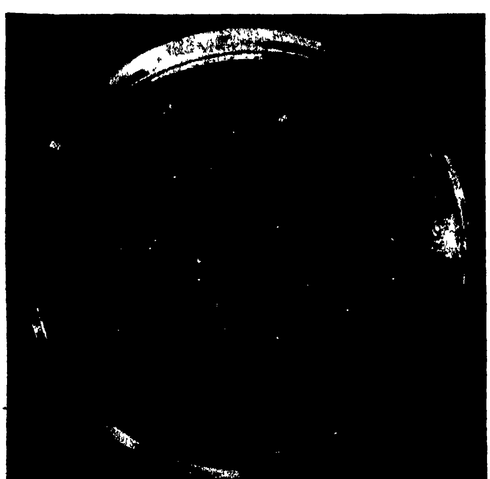
A, Renneted pure milk, inoculated with a pure culture of a gas-forming bacterium isolated from gassy curd. The gas-laden, light curd rises to surface of whey

B, Gas-forming milk organisms 1, Curd showing "Pin-holes" due to the formation of gas by the vital activity of certain bacteria 2, Sample of condensed milk "blown" with gas formed by a particular kind of yeast.



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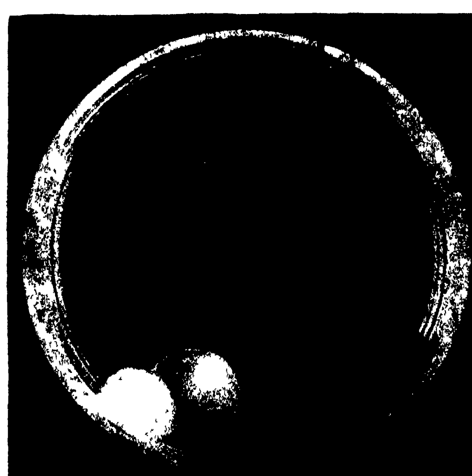


D

C, The cultivation of Bacteria in a Petre Dish. Each little white speck represents a "colony" of bacteria that started from a single germ.

D, Petre dish culture of Bacteria from a good sample of Creamery Butter. The minute white points represent colonies of lactic-acid-forming bacteria. The large circular white patch is a colony of putrefactive bacteria (that arose from a single indi

packages, when it covers the butter paper or even the surface of the butter itself with a cobwebby or feltlike growth, which rapidly passes into a spore condition, and then presents the characteristic green powdery appearance so well known to housewives. This mould feeds not on the butter itself nor on the paper, but on the buttermilk that exudes from samples of butter in which the milk has not been sufficiently washed out. Certain species of Penicillium, however, aid in the ripening changes that take place in certain cheeses, such as Stiltons and Gorgonzolas.

Many other kinds of bacteria may be occasionally present as contaminations in milk, of which the following may be noted: (1) *Pigment-forming Bacteria.*—The vital functions of many forms of bacteria are frequently accompanied by the production of particular colouring matter, of which red, yellow, greenish, and blue are perhaps the most common. Many of them will fail to show their characteristic colour in the presence of acid. Sometimes, for example, after pouring out milk, the bottom of the containing vessel will show a red-coloured deposit which may be readily mistaken for blood, but which is really the product of bacterial growth. In other cases the milk may become more or less greenish in colour, accompanied by a very unpleasant odour. This again is due to a species of bacterium that has reached the milk through a contamination. (2) *Slime-producing Bacteria.*—Milk not unfrequently becomes so slimy that it may easily be drawn out into quite long strings. Here again the change is due to special fermentations brought about by micro-organisms. In the manufacture of Edam cheese this particular kind of fermentation is desired, is indeed necessary in order to obtain the characteristic texture and flavour. (3) *Rennet-forming Bacteria.* — Many forms of bacteria produce enzymes or ferments that act on milk similarly to rennet, that is to say it induces the coagulation of the casein. Very frequently these same bacteria produce a peptonizing enzyme as well, so that the curd so formed is eventually digested or made soluble, so that the milk after a time becomes quite clear or transparent. When pasteurized milk curdles, as it occasionally does if kept long enough, it will be found that it does not become sour. The curdling is not due to acidity but to the direct action of a rennet ferment, produced by a bacterium that resisted the heat of pasteurization. (4) *Butyric-acid-forming Bacteria.* —These may be present in milk contaminated by intestinal matter, and if carried over to the butter may under favourable conditions produce rancidity. (5) *Pathogenic Bacteria.*—These disease-producing bacteria are the most serious germ contaminations of milk. Numerous cases have been recorded where the germs of tuberculosis, typhoid fever, scarlet fever, and diphtheria have been distributed through the agency of milk. (6) *General.*—Many other kinds of bacteria may be found in milk, some giving distinctive characters to it, while others appear to have no discoverable effect upon it. As examples of the former, we may mention cases in which, as resulting from bacterial action, milk may acquire distinctive tastes or odours, such as a soapy, a bitter, or an objectionable oily taste, or it may give off a turnipy or other smell. It may here be noted that 'koumiss' or wine-milk, largely used in different parts of Asia as a beverage, is produced by the alcoholic fermentation of lactose in milk. 'Kephir', again, is a fermented milk used by the people of Caucasus, and is the product of a triple fermentation—lactic, alcoholic, and peptonizing; the kephir grains used as a 'starter' of the fermentation being apparently associate masses of bacteria and yeasts.

Having thus shortly reviewed the usual and possible bacterial contaminations of milk, we may next proceed to enquire as to the ordinary sources of such contaminations. These are for the most part derived from the body of the cow, the hands or clothing of the milker, unclean utensils, and dust-laden air. The body of the cow usually contributes a large share of the most troublesome species of bacteria. Unless the cow is well groomed, her flanks and tail are often coated with dried filth, while the udder and under-body are always shedding hairs, all of which may be loosened and start falling once the milking begins. The dirt and hairs carry vast numbers of micro-organisms into the milk pail. Then again, a little milk always remains in the teat passages after each milking, and offers a good medium at body temperature for the development of bacteria. By the time the next milking comes round, this residual milk is particularly rich in bacterial life, the numbers not unfrequently reaching many thousands per cubic centimetre. Obviously the first-drawn milk from each teat should be discarded. Unclean hands, and dusty or dirty clothing of milkers, will often contribute very objectionable germs to the milk, while imperfectly cleaned pails are unquestionably fruitful sources of bacterial contamination. All empty milk utensils should be at once well scalded or steamed in order to kill all bacterial life, remembering that there is a great difference between an apparently clean vessel and a sterile one. Lastly, the air itself is the source of much bacterial contamination If cows are milked indoors the greatest care should be taken to carry on the work in an atmosphere free from dust. Disturbance of dry fodder or bedding liberates dust, and dust particles are, as we know, efficient carriers of germs, and more likely than not germs of a really troublesome character. We may here remark that it is not so much the number as the character of the bacteria that matters, and that bacteria associated with dirt may be taken to be of a much more harmful nature than those that would reach the milk from the comparatively pure air of a field. Another point may be emphasized. Apart from pathogenic forms, that are always dangerous, it very much depends upon the use to which the milk is to be put, whether any particular race of germs will or will not prove troublesome. If milk is to be used for ordinary domestic purposes, it is important to prevent as far as possible the lactic fermentation that produces sourness; whereas if the milk is to be used for butter or cheese making, the presence

of lactic-acid-forming germs is desired. So far as one knows, the ordinary gas-forming bacteria cause, on the other hand, no trouble to the buttermaker, but milk containing germs of this character is absolutely worthless for cheesemaking. The spores of Mucor or dung mould, while harmless in milk intended for direct consumption or for churning, are most undesirable if the milk is to be made into soft cheeses. From what has been said it will be easily understood how difficult it is to get milk even approaching purity so far as bacterial contamination is concerned, although comparative purity can be secured by an intelligent attention to cleanliness in milking and subsequent handling. All untreated commercial milk contains a varied bacterial population, and is therefore liable sooner or later to undergo a fermentative change. Several methods may be employed either to delay or prevent these changes. A freezing cold will render the germs inactive, while a temperature approaching boiling will actually kill them. The milk warm from the cow has a temperature most favourable for bacterial growth and development, hence the utility of chilling it as quickly as possible after milking, and keeping it cool until required for use. It is possible to keep milk unchanged in frozen blocks for an indefinite period, melting it by heat as required for use, as indeed is the practice of some milk suppliers in Denmark. It is well known that 'scalded' milk keeps sweet longer than raw milk, because, of course, the germs that produce the souring change get killed by the heat. In this connection it must be remembered that some bacteria have the power of producing spores, and that when in this state they are far more resistant to heat than if they are in their ordinary active or vegetative state (see BACTERIA). The killing temperature of active bacteria may be stated in general terms to be about 55° C., while most spores, on the other hand, will survive ordinary boiling. A treatment by heat, having for its object the killing off of the non-sporing bacteria only, is called pasteurization, while a process that destroys the spores as well, and so renders the medium devoid of all life, is known as sterilization. Milk merely pasteurized has not therefore the keeping qualities of sterilized milk, but for some purposes pasteurization is preferable to sterilization. Sterilization changes the colour, taste, and chemical composition of milk, rendering it objectionable to some palates, while carefully pasteurized milk leaves it practically unchanged, excepting that it destroys the natural enzyme of the milk itself (see PASTEURIZATION). In creameries, where milk is received from so many suppliers, it is found necessary, in order to ensure an output of a good keeping butter with a uniform flavour, to pasteurize all the milk or separated cream as soon after delivery as possible. This process, however, kills off all the non-sporing bacteria good and bad, and therefore it is further necessary to re-infect the milk with lactic-acid-forming bacteria in order to enable the cream to properly ripen. This is done by mixing with the cream (when it cools down sufficiently) a 'starter' (which see), or pure culture of lactic-acid-forming bacteria. The inoculated cream is then kept at a temperature favourable to the growth and multiplication of the lactic-acid-forming bacteria, with the result that the cream 'ripens' uniformly and without taint. Butter made from cream ripened in this way has obviously high keeping qualities, as all germs other than those of the lactic-acid group are absent, and hence no putrefactive or other undesirable bacterial changes can take place. Reference may be here made to the use of preservatives in butter. Common salt is the only substance that ought to be used, as any others may be assumed to be more or less harmful to health. Boracic-acid compounds are frequently used, but as these are cumulative in their effects upon the body, physicians agree in condemning them. If butter is made from clean milk or from properly pasteurized cream ripened by a pure 'starter', the use of such preservatives is rendered unnecessary. They are only necessary to preserve butter made from dirty and therefore germ-polluted milk. A natural well-keeping butter, on bacteriological analysis, should practically only give lactic-acid-forming germs and no others. In the ripening of hard cheeses, lactic-acid-forming bacteria play an important part, especially in the initial stages. As in buttermaking, the use of a vigorous starter is of much advantage, as it not only saves time in securing the necessary degree of acidity, but it also tends to prevent the development of taints, while at the same time it improves the flavour and texture, and enables the cheesemaker to supply a more uniform product. The lactic acid unites with the casein or paracasein of the raw tough curd, forming a monolactate that differs from the original paracasein in being soluble in a dilute saline solution. The rennet used to coagulate the milk contains a peptic ferment, and this ferment digests the monolactate of casein, breaking it up into albumoses, peptones, and higher amides. This digestion of the curd is accompanied by a general softening of the cheese mass, and is regulated as to character and rapidity by variations in the two controlling factors, acidity and temperature.

In connection with this matter it should be noted that the milk itself contains an interesting ferment (galactase) that appears to act in association with the rennet ferment in bringing about these changes. It is about this stage in the ripening that the bacterial flora attains its highest development as to numbers. The final changes in ripening are apparently concerned in the breaking down of the higher amides into simpler amido-bodies and ammonia, and it is during the formation of these latter bodies that the characteristic flavour and aroma of the cheese is developed. It is very probable that these particular changes are the result of the fermentative activity of certain bacterial enzymes. In the case of Stilton cheese, a Penicillium mould takes part in the ripening, its well-known blue streaks and patches being due to the presence of this fungus. In the ripening of Gorgonzola and Roquefort cheeses, moulds play an important part, while in Camembert its characteristic semi-solid substance is produced entirely by bacteria,

and its enclosing crust by a dense growth of mould. [D. H.]

Dairy Buildings. See BUILDINGS, FARM.

Dairy Farming. See FARMING, SYSTEMS OF.

Dairymaids' Duties. — Were we questioned as to the first and last duties of dairymaids, our reply in respect to both would be something like this, viz. the constant pursuit of cleanliness—cleanliness of dress and of person, of dairy rooms and all equipments therein contained, cleanliness of everything which directly or indirectly comes into contact with milk.

All other duties are included within the 'alpha and omega' herewith denoted; and none of these is likely to be neglected, if only we are assured that cleanliness is thoroughly well attended to.

System, method, regularity in work, alert and intelligent interest in processes, and ungrudging industry whilst duties are being performed, are all met with in the trained and efficient dairymaids who control up-to-date dairies of the present time. It is not necessary that a dairymaid should be—practically—a chemist, or a microscopist, or a bacteriologist, — work under these sciences has been done for her professionally—but she has need to study the work that lies to her hand, in order to realize what fermentation and structural changes in milk do mean, and the laws under which these things occur; and she requires to know what the microscope has revealed in the dairy, and what the functions are of the bacilli which find in milk so congenial a sphere of activity. Dairymaids' duties are—more closely than many of them imagine—associated with these ubiquitous bacilli. All this is within the capacity of an educated dairymaid. [J. P. S.]

Dairy Produce.—A widespread and significant transformation has been, and still is, working itself out in British dairying since the year 1870, and the produce in many districts is wholly different now in its saleable form from what it was at the time denoted. Where cheese and butter—one or other of these—were formerly the salient products of nearly every dairy farm throughout the shires, milk alone now represents the produce of the cow. The cow is, of course, an elaborator still—as she always was —of milk, but the farmer is no longer a manufacturer of cheese or butter; he has settled down into a vendor—as it is—of what the cow produces, viz. milk, passing it on to the consumer as a liquid, without manipulating it into the solid forms of cheese and butter, as was formerly the unvarying rule.

The numbers of 'cows and heifers in calf' vary annually in the United Kingdom, an average being about 4,100,000. Mr. R. H. Rew, of the Board of Agriculture, estimates that each of these animals yields on an average about 420 gal. of milk per year, available for domestic use, which is calculated into an aggregate yield of 1,723,000,000 gal. The utilization of this prodigious quantity—which, by the way, does not include what is used in rearing calves—is summarized as follows:—

	Gallons
Consumed as milk	620,000,000
,, cheese	153,000,000
,, butter	944,000,000
,, condensed milk, &c.	6,000,000
	1,723,000,000

Assuming, as we may fairly do, that the foregoing estimates are approximately near the mark, the consumption of milk by our people—as milk, and for purposes of cookery—amounts to about 15 gal. each, but this proportion would require to be differentiated as between different classes of society. The quantity of cheese consumed amounts to about 3⅝ lb., and of butter to 22½ lb. The item of cheese seems small, but it is to be borne in mind that we import cheese largely from abroad.

Pigs may be reckoned to a large extent as an asset of the dairy, inasmuch as they are fed in a large measure on the by-products of cheese and butter dairies. See also BUTTER, CHEESE, MILK, FARMING (SYSTEMS OF), &c. [J. P. S.]

Dairy Schools.—Tuitional establishments, at once technical and scientific in scope and practice, are highly important characteristics of the new era in dairying which unfolded itself in the last quarter of the century recently closed. A generation ago they were not yet in being—were only just beginning to be thought of. But they are prominent features in the dairy world of to-day in the British Islands. Their existence is owing to the sharp awakening which occurred in the early 'seventies from a careless slumber of centuries' duration in British dairying, and that awakening in turn was the sequel of the rapidly developing foreign competition of the period in dairy products, most of all in cheese.

Ireland was early in the field with dairy schools wellnigh thirty years ago—almost literally in the field, inasmuch as the first schools were itinerant, especially in the southern shires of the Emerald Isle. They were in a way a recrudescence of the old-time 'hedge schools', but each school itself was on wheels. A covered vehicle, whose internal arrangements were designed to meet the requirements of a travelling dairy, was furnished with the equipment necessary to a dairy school that was independent, if need were, of a stationary building—a travelling school on wheels, within whose shelter an exhibition of modern dairy utensils at work could be given in view of all spectators gathered around the open doors at the rear of the vehicle. It was said soon afterwards that the route of the travelling dairy van could be traced by improvements in butter wherever it went.

Later on, the matter was taken up by some of the county councils of England in dairying shires. Special and roomy vans were built, in which all the necessary equipments for several pupils at a time, in session for a week or more, were supplied. In some cases a tent was taken along, or sent by rail—a tent large enough to accommodate pupils and also an audience to witness demonstrations. In yet other cases, farmers' empty barns were used instead of a tent, wherever suitable ones were procurable. Sometimes, indeed, certain farmers placed their

dairy rooms at the service of the authorities; which arrangement was perhaps the best of all, because the most practical, natural, and homelike.

It was soon seen, however, that these peripatetic academies for dairy tuition did not adequately meet the requirements involved in the education of a country in special arts like those employed in the making of cheese and butter. They were of a makeshift character, unsuitable to the reformation of a vast and permanent industry. The British Dairy Farmers' Association struck the true chord when it established its own dairy school at Aylesbury, afterwards removing it to Reading, where it is now doing good service to British dairying.

This example began to be copied in some of the more important and progressive dairy counties; and now, perhaps, the country at large may consider itself in fair form to supply the requirements of national dairy tuition. These county dairy schools are well supplied with the paraphernalia necessary to teaching the best that is known in dairy work, both scientific and practical. Chemistry and bacteriology, in their application to milk, cheese, and butter, are grounded in the minds of students who have desire and capacity to grasp those important subjects and to put them into practice.

The great and even extraordinary advances made in recent times in the science and practice of dairying are all embodied in the curriculum of each and all of the important schools. Obviously, it is becoming almost impossible for itinerant dairy schools to meet the complex demands of modern science in dairy work. A stationary equipment, free from chronic disarrangement, is becoming, if it has not already become, indispensable; as it is in a permanent dairy, and more so. The key of the whole situation has been found in the science of bacteriology, and this it is that is accomplishing a transformation of preconceived ideas, and of practices based upon them. It is known at last, after centuries of groping in the dark, what things are necessary to plenary success in dairy work; but at the same time it is clear that accurate training and adequate practice in the schools are necessary to a perfect mastery of the subject, lacking which failures will still continue common.

Following is a list of the chief dairy schools in England: Midland Agricultural and Dairy College, Kingston, Derby; British Dairy Institute, Reading; Lancashire County Council Dairy School, Hutton, Preston; Essex County Council Dairy School, Chelmsford; Cheshire County Council Dairy School, Worleston; Yorkshire Dairy School, Garforth, Leeds; Eastern Counties' Dairy School, Ipswich; Cumberland and Westmorland Dairy School, Newton Rigg; Shropshire Dairy School, Harper-Adams College, Newport; Warwickshire County Council Dairy School, Griff House, Nuneaton.

In Scotland: West of Scotland College Dairy School, Kilmarnock.

In Wales: Lleweni Dairy School, Aberystwith Dairy School.

In Ireland: Glasnevin Dairy School, Munster Dairy School. [J. P. S.]

Daisy (*Bellis perennis*).—This is a well-known Composite plant, abundant everywhere on commons, lawns, and in waste places. From an agricultural point of view this is a troublesome weed, scarcely to be destroyed except by careful tillage. Its stems are so very short as to be entirely hidden by the broad, flat, tufted leaves; they are prostrate, strike root readily, and have the property of producing numerous eyes at the surface of the ground, which rapidly grow into side branches, that, like the parent branch, also root with great facility; the stems being brittle, their side branches are readily separated, and then maintain an independent existence, each forming rapidly other side shoots, which will root and break off in like manner. This property has given rise to the idea that the Daisy has a creeping root; but in reality its roots are mere fibres, which strike down perpendicularly into the soil. It is because of the abundance of these rooting side branches that daisies are so difficult to destroy; mere harrowing, or spudding, or scarifying, fails to produce the desired effect. Besides, every head of flowers that is allowed to ripen sheds some fifty or sixty minute oval hairy seed vessels, which burst open in a few days after they touch the damp soil, and from the contained seeds form a fresh supply of plants. Hence the advantage of daisy-rakes in keeping lawns in order; they do not extirpate the original plants, but they prevent further multiplication by seed.

It has been recommended to persevere in the employment of the spud when daisies are abundant; but the labour attending this operation is, from the nature of the plants, endless. A better plan is to starve out the Daisy, by encouraging grass to overgrow it, and by mowing seldom. This procedure is, as a rule, very effective, for the weed is very sensitive to shade. When, however, daisies have overrun the soil, there is no remedy except paring and burning, or incessant tillage, till the very last has been removed. Top dressings of sulphate of ammonia are often effective, and tend to kill off this weed.

The Daisy must be regarded as a weed and nothing more. It has, however, had some reputation as a medicinal plant. The Swiss formerly employed an infusion of the leaves in water, or goat's milk, against hectic fevers; it has also been employed in peripneumonia, according to Haller. [J. L.] [A. N. M'A.]

Daisy, Ox-eye. See CHRYSANTHEMUM.

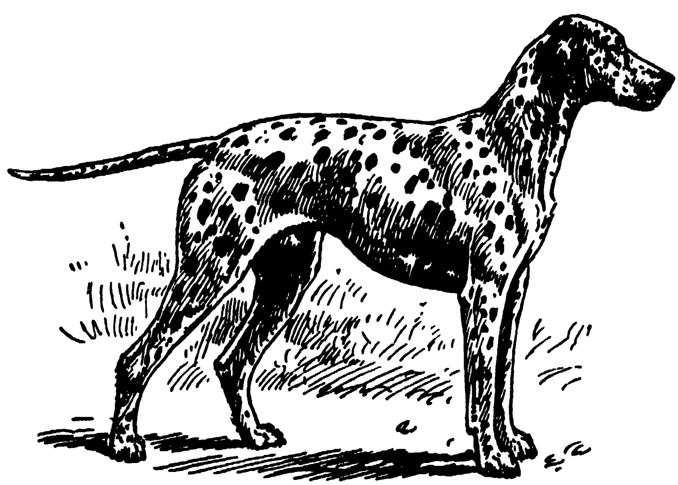
Dales Ponies.—These ponies are principally found in the upper reaches of the Wear and Tees rivers in north-west Durham, the vales of Westmorland, more especially in the neighbourhood of Kirkby Stephen, and Allandale in Northumberland. The name 'Dales' is significant of the nature of the places where they are chiefly bred. In only one or two books of reference concerning horses is particular mention made of them as a distinct breed. This is somewhat surprising, inasmuch as they are a very old breed, and most probably an original English cart-horse breed. Unfortunately they have no stud book. The place to which they are sent for sale by breeders in very great numbers is Brough Hill Fair, near Warcop, in

Westmorland. The fair is held in October, and was at one time a very important rendezvous for buyers and sellers of Dales ponies. Appleby is also a good market for these ponies. Good individual ponies make from £20 to £35 each. In conformation and build, the best type of pony very closely resembles a good miniature cart horse. The size especially favoured varies from 13½ to 14½ hands high. The neck is short, thick, well arched, and the natural carriage of the head most graceful. The general bearing of a good Dales pony is very pleasing. Face straight, wide at the eyes and nostrils, the eyes themselves being full and intelligent. Their walking and trotting action, though not so marked, closely resembles that of the Hackney. They are as a rule quiet, very docile, and easily broken. While not good at cantering, they make excellent trotting, harness, and riding ponies, and have great powers of endurance. The great stamina of these ponies is one of their strongest points. For their size, their legs have bone of good flat quality and plenty of it. Their feet are sound and hard though somewhat steep. The best of them have nicely sloping shoulders, and short, thick, shapely bodies of good depth of girth. They have particularly strong muscular backs, short, slightly sloping rumps, thick thighs, and hocks well set down. Their general appearance is altogether indicative of great strength in a small compass. Fine silky hair at the back of their fetlocks and above denotes good breeding. Greys, browns, and blacks are favourite colours. In their native homes they are largely used as the general-purpose horse of the pastoral farms. Away they are eagerly sought, for pit-bank work, milk floats, tradesmen's and general hawkers' carts.

Originally these ponies were chiefly used to carry in specially constructed wooden saddles the ore from the lead mines to the smelting works. Some of the older farmers remember them as being similarly used to carry coal of inferior quality with which to burn lime in the farm limekilns Unfortunately a limekiln on the farms, where they were in former times of frequent occurrence, is now a great rarity. On many of the farms in the districts mentioned, carrying hay by means of hay sledges is still a common practice. The Dales ponies are particularly intelligent and quick at this work. A good pair, if carefully driven, are sufficiently strong to work consistently an ordinary mowing machine. Most of the land where these ponies are bred is either fell or under permanent pasture. Many of the farmers are small holders, and on their holdings use a single-horse mowing machine with shafts. A good Dales pony is frequently the only horse kept for this and other work.

Speaking generally, these ponies are sound, active, and very hardy, and extremely surefooted. Thoroughbreds and hackney stallions out of good pony mares usually beget offspring which make excellent roadsters. For farm work on pastoral farms, however, such crosses are not especially liked, as in nearly all cases the progeny are of greater height and lighter in bone than farmers favour. Swiftness and action are secured at the expense of strength, hardiness, and durability. On the other hand, the progeny of good pony mares by lighter cart-horse well-bred sires of the Clydesdale type are greatly liked for general farm work and the carting of minerals of various kinds from the mines and quarries to the nearest railway stations. Pure-bred Dales ponies are of such general all-round excellence that it seems regrettable that sufficient interest and enthusiasm amongst breeders have not as yet resulted in the establishment of a stud book devoted to their interests and welfare. [F. P. W.]

Dalmatian Dog.—It is very much to be regretted that the dictates of fashion have of late years ceased to insist upon a Dalmatian dog being an indispensable addition to the equipages of the wealthy. The combination of a well-turned-out landau, a pair of high-stepping 16-hand bays, with a well-marked spotted dog in attendance, such as used at one time to be a common feature of the afternoon parade in Hyde Park, was essentially a British institution, and its disappearance has been a source of sorrow to many. Still more is it unfortunate that its dissociation with the carriages of the aristocracy should have led to the withdrawal of a great deal of the patronage and support of dog breeders from the Dalmatian, as the merits of the breed entitle it to a wider recognition than has been extended to it of late.



Dalmatian Dog

The Dalmatian, whose foreign ancestry is obvious from the name he bears, possesses merits of his own far above a mere love for the society of horses, and there is plenty of evidence forth-

coming to show that the intelligence of the breed is far higher than is imagined, and that it possesses not merely very high scenting powers, if they happen to be properly developed, but hunting interests of a superior order. In fact, it is well known that Dalmatians have been trained for field purposes, and have fulfilled the duties of gun dogs most admirably. This, perhaps, is not surprising when the close resemblance that exists between the Dalmatian and the Pointer is borne in mind; but as the faculties of the former have not been developed it must necessarily follow that there can be no serious comparison drawn between the merits of the two varieties as dogs to be used for the purposes of shooting-men.

The skull of the Dalmatian is flat and broad, the muzzle being rather long and truncated as in the case of the Pointer; the eyes should be dark, a yellow one being greatly disliked as it detracts immeasurably from the appearance of its possessor; the ears should be carried flat against the sides of the head and never raised. The neck should be of a good length, free of any approach to dewlap, and elegantly set on to shoulders which must be both long and sloping, in order to provide that activity which is so great a characteristic of the breed. The chest must be nicely let down and of fair width, stamina being more sought for in this variety than extreme speed, and the fore legs should be rather long, perfectly straight, and heavy in bone, in order to carry their possessor comfortably through a hard day's work, whilst for the same purpose the feet should be round, compact, and provided with thick soles. The body is rather long, as are the back ribs, so as to supply the desired power at the loins, the tail being of greater length than that of the Pointer, free from curl and carried straight. In weight a Dalmatian averages from 40 to 45 lb., the bitches being rather lighter than the dogs. Last comes the all-important subject of colour, for exhibition purposes an essential point in connection with the breed. This should be pure-white relieved by innumerable black or liver-coloured round spots, varying in size from that of half a crown to that of a sixpence, and distributed all over the body, limbs, ears, and tail, large, irregular patches being regarded with great disfavour. It may be added that Dalmatian puppies are born white, the spots commencing to appear when they are a few weeks old. [V. S.]

Dalradian, a term proposed by Sir A. Geikie in 1891 (Quart. Journ. Geol. Soc., vol. xlvii, Proceedings, p. 75) for an extensive series of metamorphic rocks of doubtful age, found in the west and north of Ireland and throughout a great part of the Scottish Highlands. The name is founded on that of the old Irish kingdom of Dalradia. The Dalradian rocks may include pre-Cambrian, Cambrian, and Silurian masses mingled by earth-pressures and earth-movements at some epoch about the opening of the Devonian period. Mica-schists, quartzites, and crystalline limestones, often preserving their original bedded structure, are the typical Dalradian rocks. They have often been invaded by granite, which has altered them still further. They extend from the north of Sutherland to the Highland border near the basins of the Forth and Clyde, and are only here and there, in this great Grampian area, concealed by younger deposits of Old Red Sandstone. The occasional limestones are naturally sought out and quarried in a region otherwise very poor in lime. The mica-schists yield good ferruginous clayey soils, but mostly form mountainous moorlands, in the hollows of which the principal lakes of Scotland have gathered. The more fertile lands occur as deltas in these lakes, or in the alluvial flats along the valley-floors. While forests can flourish in the mica-schist areas, notably in the Trossachs and at Killiecrankie, the quartzites are usually barren, frequently giving no hold to vegetation, and rising in conical peaks, like that of Schiehallion, above the surrounding moorlands. Similar wild country is formed by the Dalradian rocks in the west of the counties of Mayo and Galway, and through a large part of County Donegal. The north-east of County Antrim also reveals Dalradian rocks, which are clearly a continuation of those on the opposite headland of Kintyre. Except for occasional patches of glacial drift, and the alluvial stretches above referred to, the areas occupied by these crystalline rocks, with their steep surface-forms and peaty hollows, offer little inducement for tillage. Large sheep-farms have been established on them in Scotland, but in many parts even these have given place to deer preserves; while the lack of agricultural employment and the closing of old 'houses of call' have made the Grampian region more difficult to traverse from east to west than it was half a century ago. [G. A. J. C.]

Damping off, a diseased condition frequent amongst seedlings and cuttings, but it may also occur on fruits and foliage.

SEEDLINGS. — Damping off is recognized by the plants dying off in clumps. So frequently is the fungus *Pythium de baryanum* present that it has come to be known as 'the damping-off fungus' (see FUNGI—'Phycomycetes'). Almost any kind of seedling may be attacked, although a preference is shown for cruciferous plants, such as cress and cabbage. The spores germinate in the soil in moisture and heat, and produce fungus-filaments which penetrate the seedlings at the surface of the soil; the stem becomes soft, and the upper part topples over and rots away. Tree seedlings are more frequently attacked by *Phytophthora omnivora* (see BEECH—PARASITIC FUNGI), or by *Pestalozzia Hartigii* (see PINE—PARASITIC FUNGI). It is also likely that many other fungi living in humous soils may become parasites on young plants.

Treatment.—Dampness and overcrowding are favourable conditions, and treatment consists in improved ventilation, admission of sunlight, and thinning out. Fresh soil should be used, and where damping off is likely to occur, sterilization is advisable (see STERILIZATION).

CUTTINGS. — During the period of rooting, excessive moisture favours the growth of fungi, especially species of *Botrytis*, which form a dirty-grey mould and cause rotting of the cut-

tings. *Treatment* as in case of seedlings, with as little overhead watering as possible.

FRUITS.—These drop off or rot before mature (see GRAPE, APPLE, AND CHERRY, PARASITIC FUNGI OF). [W. G. S.]

Damson, a small black-skinned, oval-fruited variety of the common Plum, possessed of a distinctive and somewhat tart flavour, and highly esteemed for culinary use in a variety of ways, particularly the confection known as Damson Cheese. This fruit is not commonly commercially cultivated upon a considerable scale, and although abundant in some localities, as the tree generally either bears very heavily or scarcely at all, in some seasons genuine damsons, as distinct from small black plums, are difficult to obtain. The Damson attains to considerable dimensions, and is of a bushy, sloelike habit. Its peculiar merit is that it will succeed under indifferent conditions; indeed it is very suitable for forming a tall hedge, but it is not irresponsive to good cultivation. The best varieties are: Bradley's King, Crittendens, Herefordshire Prune, and Shropshire. The fruit is ripe in September. For cultural details, &c., see PLUM. [W. W.]

Damson, Insect Enemies of. See ENTOMOLOGY, ECONOMIC.

Dandelion (*Taraxacum officinale* or *T. dens leonis*).—This well-known perennial herb is very common in dry or sandy meadows and waste lands, and is sometimes found on moist moors. It belongs to the nat. ord. Compositæ, and is a typical representative of that division of the order which is marked by the presence of milky juice or latex, and the strap-shaped or ligulate flowers in the head. In a Daisy head only the white flowers are strap-shaped, whereas in the Dandelion all the flowers are so. The plant is composed of a long stout taproot, which grows down into the depths of the soil. Towards the surface this root is crowned by a short stock, which produces leaves arranged in the form of a rosette. These leaves are spread out on the ground so as to cover as much surface as possible, and as one rosette dies off another takes its place, but still applied to the surface of the ground, for the root contracts so as to pull the new leaves down to the right position on the ground. Everyone knows the leaf of the Dandelion by its sharp-pointed lobes sloping back towards the base of the leaf. For reproductive purposes special flower-bearing shoots are produced, and these also are very characteristic, for each is composed of a hollow leafless stalk terminated by a single large head of yellow flowers surrounded and protected by a special set of overlapping green scales. When the fruiting stage is reached, the protecting scales bend back so as to let the fruits go free and spread the plant all around. The wind is the spreading agent, and a very effective agent, for each fruit has a tuft of white hairs placed at the end of a stalk which crowns the seed-case, and this tuft of hairs acts as a parachute.

The seed-case is leatherlike, 2 mm. long and ½ mm. broad. The surface is marked by ribs, and minute spines occur towards the apex, which is prolonged into the stalk (beak) for the tuft of hairs. Within the seed-case there is a single seed, from which the new Dandelion plant arises.

For eradication, hand pulling or forking may be resorted to, and weed killers may be applied. For preventing spread by seed, the flowering shoots should be removed.

Medicinally, Dandelion root is considered as favouring perspiration, and as a tonic. It used to be a favourite remedy for diseases of the liver and for constipation.

Dandelion root, when roasted and ground, is a substitute for coffee and for chicory. The leaves are a favourite food for rabbits, and cattle also occasionally eat them. [A. N. M'A.]

Dandie Dinmont Terrier.—Unquestionably this most desirable variety of Terrier is indebted for a great share of its popularity to Sir Walter Scott, whose allusions to Dandie Dinmont in the pages of Guy Mannering have been associated by hosts of that great writer's

Dandie Dinmont Terrier

admirers with the existing breed of Terrier. But, of course, the present representatives of the race trace their genealogy back, not to the terriers of the fictitious Dandie Dinmont immortalized in Guy Mannering, but to those of one James Davidson of Hyndlee, who existed in the early period of the 19th century, and who possessed a famous strain of terriers. The appearance and behaviour of James Davidson reminded his friends so much of Sir Walter Scott's character in the book, that they are reported to have jocularly referred to him as Dandie Dinmont, and this being so, it is not surprising that when a distinctive name was wanted to identify his breed of terriers, the selection should have been what it was.

The derivation of the name Dandie Dinmont is therefore accounted for without much difficulty, but a very much more formidable task lies before those whose duty it may be to satisfy their readers regarding the sources from which these most interesting and useful dogs originally sprung. To judge by the appearance of not merely the modern Dandie Dinmont, but from the specimens seen thirty years ago, and

also by old illustrations of the breed, it appears reasonable to infer that it owed its existence to an Otterhound cross upon the Terrier, the probability of this having been the case being increased by the knowledge that the sport of otter hunting was more generally indulged in in Scotland a hundred years ago than now. Not merely does the appearance of the Dandie Dinmont strongly support the above theory, but the strength of the argument is increased by the predilection of the Dandie Dinmont for hunting vermin in water,—indeed most packs of otterhounds are even nowadays strengthened by the addition of a few of these terriers, whose services are found to be most valuable in cases of difficulty, when the hunted otter seeks safety in places which are inaccessible to the large-sized hounds.

The value of the breed as a vermin dog renders it a very useful dog to the agriculturist whose premises may be infested by rats, stoats, and larger forms of animals which prey upon his stock. Of a certainty no hardier or more courageous breed of Terrier exists than the Dandie Dinmont, whose powerful jaws enable him to inflict the severest punishment upon the subject of his attack, whilst the density of his coat and his robustness of constitution combine to resist the effects of exposure to cold and wet to quite an exceptional extent. It is a peculiarity of many Dandie Dinmonts that if they are placed at a disadvantage when encountering larger and heavier animals than themselves, they fight on their backs, and when in this position some will use their powerful legs and claws with considerable effect upon their opponents, whilst should they get a hold of his throat with their teeth, the result of the struggle is almost invariably favourable to the Dandies.

Before proceeding to describe the structural formation of the breed, it may be mentioned that the recognized colours are mustard, *i.e.* a yellowish fawn, or pepper, a bluish-grey. The puppies are born of a black-and-tan colour, which often causes their owners, if they have no experience of the breed, to imagine that the parents, or at all events one of them, are not pure specimens of the breed; but this is not the case, and the puppies will be sure to change their colour when they get their first coats. The skull of the Dandie Dinmont is large and domed, and is made to appear larger still by the topknot or tuft upon it, whilst the jaws, which should be of fair length, seem shorter than they really are owing to their massiveness, as a power to inflict punishment is one of the most important characteristics of the breed. As a consequence the teeth should be very large and strong; moreover, any irregularity about them is regarded as a fault, an overhung jaw in which the upper teeth project beyond the lower ones being regarded by many breeders as suggestive of a Bedlington Terrier cross, whilst an underhung mouth with a protruding lower jaw is usually accepted as betokening the presence of Bulldog blood.

A rather peculiar feature of the Dandie Dinmont is the largeness and soft expression of his eyes, which are full and round, and so gentle-looking that they provide an exception to the general rule, which lays it down that the eye of a Terrier should be rather small than large, and inclined to be sunken in the head. The ears, too, differ from those of most terriers in size and shape, as they are large, and are carried flat to the sides of the head. The neck is short and rather thick, the body long and somewhat arched at the loins, the ribs being well sprung, whilst the chest is deep and let down close to the ground. A feature of this breed is the shortness and massiveness of the fore legs, which are decidedly twisted in shape in the case of some very good dogs, but the straighter bone is to be preferred. The hind legs are proportionately longer, and hence the rise or arch at the loin, the effect of which is increased by the shortness of the back ribs, which gives the body a rather tucked-up appearance. A long coat is not appreciated by breeders of Dandie Dinmonts, who prefer that their dogs should possess a good weather-resisting jacket of rather a pily texture; it being usually the case that the coat on the lower parts of the body is much softer than that on the back, whilst the texture of the hair on the topknot should be quite silky. Eighteen to twenty-two pounds is a good weight for these courageous, excellent vermin terriers, and it may be added that though suspicious of strangers, they are most faithful companions of those they know. [V. S.]

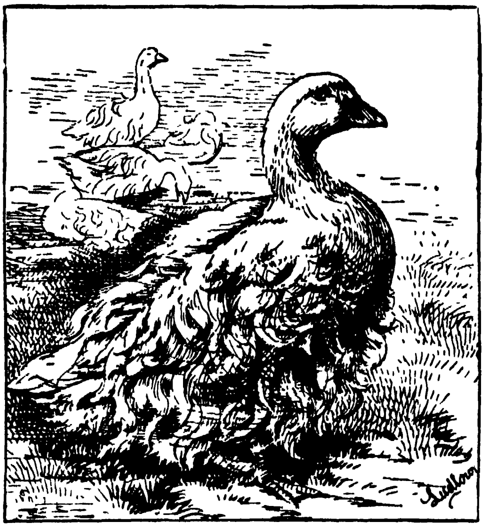
Dandruff.—The natural desquamation of the cuticle results in the production of scales of the cuticular or surface layer of the skin, such scales or scurf being known as dandruff. It is not a disease unless produced in excessive quantity In certain forms of indigestion, and in circumstances of poverty, branlike scales appear in great numbers on cattle, and cease to be shed when better conditions of bodily health are attained. It is known as pityriasis, and occasions some trouble in horses when once established. Good grooming and attention to general health, with remedies known as alteratives, usually succeed in removing any excess of dandruff. [H. L.]

Dangerous Animals. See ANIMALS, LAWS REGARDING

Danubian Goose.—Throughout eastern Europe goose breeding is extensively followed, and the trade done in these birds is very large indeed. As might be expected, types are to be met with differing considerably from those found in western Europe (see GEESE, BREEDS OF). One of these is the Danubian, or, as it is sometimes termed, the Sevastopol. They were first introduced into Britain about the time of the Crimean War, from which fact and other evidence obtainable it would appear that these geese are found in south-eastern Europe and southern Russia, though we have not met with them there except to a very limited extent, in which cases the peculiar feature mentioned below was not developed very fully. As a rule, the specimens met with in Continental exhibitions are pure-white in plumage, though we have reason to believe that a pure white is not general in the districts where they originated, and particoloured geese (see SADDLEBACK GOOSE)

are largely distributed throughout the eastern and northern sections of Europe. In shape the Danubian is long in body and somewhat shallow, with a fine neck and head, as a consequence of which it resembles the duck. Probably it is distinct in its development from the Roman (see GEESE, BREEDS OF), Embden, or Toulouse. The feature which marks it out from all other races is the length of the wing, back, body, and tail feathers, which are narrow, often curled, and trail behind like streamers. As the wing feathers are not webbed the birds cannot fly easily. One reason, therefore, which will explain any preference there may be for these geese, is that in a country where feathers form an important part of the return, any bird which is heavily supplied in this direction has an added value, although it may have a somewhat bedraggled appearance. It may be here mentioned that curled feathers are of greater value than those which are straight. In size these birds range from 8 to 11 lb., which is the general average in southern and eastern Europe. That they can be bred larger is shown by the fact that specimens bred in Britain and France have reached 15 lb. They are moderate layers, but very faithful as sitters and mothers. In a country where the conditions are favourable, such as the vast plains of southern Russia, they find all their food, and are necessarily good foragers. They carry a considerable amount of flesh, and being quiet in disposition fatten easily, and the meat is excellent in flavour and quality.

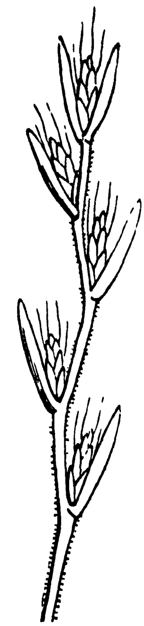
[E. B.]



Danubian Goose

Darnel. — Darnel or Darnel Rye Grass (*Lolium temulentum*) is an annual weed grass sometimes found in abundance in the wheat crop. Its ear is a two-rowed spike and bearded like that of Italian Rye Grass, but distinction is easy, for the outermost scale of the spikelet (glume) is as long as the whole spikelet in Darnel Rye Grass, but only half as long in Italian. This weed gets its agricultural importance from the circumstance that its seeds are often poisonous, and so if Darnel is abundant in the wheat, the flour made from such crop will contain the ground grains of Darnel as well as those of wheat. Bread made from this flour often produces poisonous effects, headaches, drowsiness, and so forth. To prevent the contamination, care should be taken that no Darnel seeds are present in the seed wheat. The Darnel seed closely resembles that of Italian Rye Grass, and is quite unlike the wheat grain. If Darnel appears in the crop, its seeds should be removed before grinding the wheat into flour.

[A. N. M'A.]



Darnel (*Lolium temulentum*)

Dartmoor Ponies.—As is the case in the breed of ponies in the New Forest, it is to be feared that the original type of British pony has been somewhat lost by indiscriminate crossing, and by the pernicious custom of those exercising the rights of common turning out young stock, during the summer, of no particular type, or at any rate of a type totally different from what is wanted to maintain the breed of real ponies. These are often two-year-old colts, and the harm it is possible for them to do is almost incalculable. However, there are many true and very handsome ponies on the wilder parts of the moor, and it is gratifying to know that considerably more pains are being taken to preserve the old stamp

It is very difficult to draw a distinct line between any of the native breeds, but it might be said that the Dartmoor ponies in their heads and eyes are slightly more like their Welsh brethren, from which they are only separated by the Bristol Channel.

Of course the uses to which they are put, or the markets they are bred to catch, have caused considerable variation in size and quality, but it is probable that the best type of pony for Dartmoor should not under present conditions exceed 13 hands high, though, of course, if the land can carry them and feed them well all the year round, the larger the pony, provided it has quality, the more valuable the stock is.

The land on which they are bred is possibly better than the New Forest, and it certainly affords them more dry beds, which is a very important factor in these semi-wild breeds.

Their owners are mostly men without a great deal of capital, and consequently it is incumbent on those who are able to do so to assist them to keep up what might be a valuable asset to the country generally.

It is satisfactory to know that this is the case, and district committees work for the improve-

ment of stallions, and endeavour to prevent undesirable animals from being turned out.

The management of the common lands is somewhat different from that in vogue in the New Forest. 'Moormen', as they are called, pay a sum for certain portions of the moor, and let out the grazing to others.

These men naturally have their living to make, and it is difficult, if not impossible, to dictate what they shall or shall not take in.

It would appear that Dartmoor might be a very suitable area to try what government supervision could do in aid of horse breeding, as the moor belongs largely, if not entirely, to the Duchy of Cornwall.

The true Dartmoor pony is quite invaluable as a foundation stock, and, as in the case of all the other mountain and moorland breeds, increases considerably in size, if well kept when young, while their hardiness, intelligence, and surefootedness is unsurpassed. But people who go with preconceived ideas, and with only one type of horse in their mind's eye, are totally unable to judge what they are capable of, not only in the way of breeding, but also in the way of work. It is often objected that Dartmoor ponies have big ugly heads, but a moment's thought will show the reasons of this fault if it exists. In the first place, as is mentioned above, two-year-old colts, often with much cart-horse blood, run on the moor, and thus graft their ugly heads on their stock; and secondly, stock so begotten cannot stand the winter weather and cold winds, and stand huddled up with their hind quarters tucked below them and their heads hanging down, and so grow misshapen See also NEW FOREST PONIES. [A. C.]

Dartmoor Sheep.—The Dartmoor Sheep is one of the breeds which is confined to a restricted area in Britain, and it is but little known outside its own district. It is none the less a useful and interesting breed, well adapted to the high district in which it is kept. Dartmoor is a large tract of forest and moorland in Devonshire lying between Tavistock on the west and Exeter on the east. Its length is about twenty miles, and the breadth fourteen. Its total area has been computed as between two and three hundred thousand acres of wild, varied, and uncultivated land. It is covered in many places with immense rugged rocks and vast masses of granite, so confusedly scattered as to give one the impression of their having been ejected by volcanoes. Its broken, irregular surface has been appropriately compared by one writer to the long, rolling waves of the Atlantic Ocean fixed into solidity by some powerful influence. To the north-west are large tracts of swampy land, dangerous to the cattle which graze on the scanty herbage. The peat obtained from these bogs affords useful fuel to the moormen, who keep sheep and cattle, and look after the flocks and herds of other people. The general elevation of Dartmoor is from 1000 to 2000 ft. above sea level. Just as in Cumberland there is no visible line of demarcation between Skiddaw Forest and the adjoining fells, so on Dartmoor no fence separates the moor from the forest, though the actual boundary line is known. The forest is largely in the parish of Lydford, and belongs to the Duchy of Cornwall. Although, as the term 'forest' suggests, it was once covered with timber, the only remaining wood is dwarf scrubby oak. Thousands of acres of this forest land have been cleared, and at various places are to be found the shafts of exhausted or abandoned tin mines. Such is the district in which we have the home of the Dartmoor sheep.

Unfortunately there is no recognized society or flock book for this breed, and therefore no official statement of points which are considered correct for specimens of pure type. The consensus of opinion, however, of the best breeders, and of those who generally exhibit specimens at local and the great national shows, is that the head of the ram should be strong and masculine, and that both rams and ewes should be free from horns, though occasionally a ram is found with the rudiments of horns or 'slugs'. Dark markings on the face and on the legs are liked The ears should be thick, with a tanned appearance inside, the outside being covered with short hair. The forelock, or 'love lock' as it is called, on Cotswold sheep, should not be hair but good wool, characteristic of that found on the whole body. The fleece should be long and lustrous, hanging in purls or skeins, and often measuring as much as 18 in. These purls of wool have a glossy, silky appearance, and the Dartmoor farmers attach great importance both to the quality and quantity. An average for a flock of ewes of mixed ages might be put at 10 to 12 lb Yearling rams cut over 20 lb. It is recorded that a ram from the flock of Mr. Ward in 1891 cut as much as 33 lb. These sheep are shorn about midsummer, almost invariably in the yolk or unwashed. Lambs also are always shorn, and often next time, as hoggets, will clip wool from 12 to 15 in. long. After bringing up one or two lambs, ewes will sometimes cut as much as 14 lb., or half a tod of wool. It is recorded that a prizewinning flock in the year 1865, consisting of 182 adult sheep and 109 lambs, cut 2490 lb. of wool, which sold at 1*s* 6*d*. per lb., thus making a total of £186, 15*s*, or an average of 12*s* 6*d* per sheep, including the lambs. These figures will show how important the clip of wool was to the farmer in former days, as compared with present prices. A typical ram of this breed should have strong bony legs. As a class they are good walkers, this being necessary, as they often have a long distance to travel. The 'scrag' should also be well developed, indicating plenty of lean throughout the whole sheep, as well as strength of constitution. No objection is taken to the ram or ewe having a black muzzle. Breeders are particular about the skin of the sheep being of a clear pink colour, spoken of locally as 'bright-red'. The loin should be firm and broad, and the ribs well arched. The mutton is of prime quality. It is a sheep which carries a good quantity of lean meat, and altogether fattens evenly. These admirable qualities make them favourites with the butchers, especially those who supply miners in the neighbourhood of Tavistock and other districts. They also

Photo Chas Reid

DARTMOOR PONY STALLION—"GOLDFINDER"

GROUP OF DARTMOOR SHEEP

meet with a ready sale at Plymouth and Devonport. The miners, living so much underground in a hot and generally unpleasant atmosphere, are fastidious in their appetites, abominating fat meat, but they highly appreciate the local Dartmoor mutton.

In selecting a ram, a thick tail is considered to be essential. Perhaps there is no breed in which the feeling of and handling the tail has so much to do with the general estimate of the qualities of the sheep. It is quite a common saying among the farmers who have to do with Dartmoor sheep that 'a good tup will never dirty its tail'. That somewhat crude statement simply means that the animal has such good sound digestion and constitution that the varied herbage upon which he has to subsist can be properly assimilated. This is important, not only for the ram, but quite as much so for his progeny. Sheep which are relaxed, and soil the wool with their excreta, are so much more liable to the attacks of the 'fly'. Every precaution that can be taken to minimize this trouble is essential, as the sheep roam over such a great area of country, making it difficult to catch and attend to those which might be 'struck' by the fly. It is largely on account of this that the custom prevails of shearing the lambs. The fly seldom deposits its eggs upon shorn sheep, or at least they find it much more difficult to do so.

Dartmoor ewes are exceptionally good mothers, and the proportion of twins is about 50 per cent., thus giving 150 lambs for 100 ewes. The ewes crossed with a Southdown ram bring some very fine fat lambs of exceptionally good quality. The climate of Devonshire enables the farmer to lamb the ewes in the open. This is generally done in the small and sheltered fields in the valleys during the middle of February and early in March. The lambs are hardy, and born with plenty of energy. The shepherds jokingly say that 'as soon as the lambs are born they get up, blow their nose, shake their ears, and suck their dam before you have time to look round'. The 20th May is the usual date for ewes and lambs to be turned out on the moors, where they remain until the end of September, when the lambs are generally sold to farmers, who feed them during the winter on turnips and other roots. Though some few of the wethers are sold at about fifteen months old, the greater proportion are kept until two or three years of age. There is no doubt that this matured mutton has more nutritive qualities and is better flavoured than the young mutton so commonly sold in our midland districts. As a well-known breeder has observed: 'The Dartmoor sheep is like port wine, it takes time to mature; but when got to perfection is a grand animal, and a saddle of his mutton takes a lot of beating'.

It is computed that there are something like five hundred flocks of this breed, more or less up to the acknowledged standard of purity, occupying about one-fifth of the entire county of Devon. Draft ewes are commonly sold at Tavistock Goose Fair at prices ranging from 35*s.* to 40*s.* These are bought by farmers of better land, who get a final crop of lambs from them by a Leicester or Devon long-wool tup, fattening both ewe and lamb off as soon as possible. Dartmoor rams make for breeding purposes from 5 up to 15 guineas, and they are often used on Leicester or Devon long-wool ewes to produce tegs of quality with lean meat for the butcher. It is an interesting fact, and one which was reported upon more than a century ago, that these sheep seldom or never contract the 'rot' due to the fluke parasite, *Fasciola hepatica*. This pest, so destructive in many districts, is most prevalent in abnormally wet seasons.

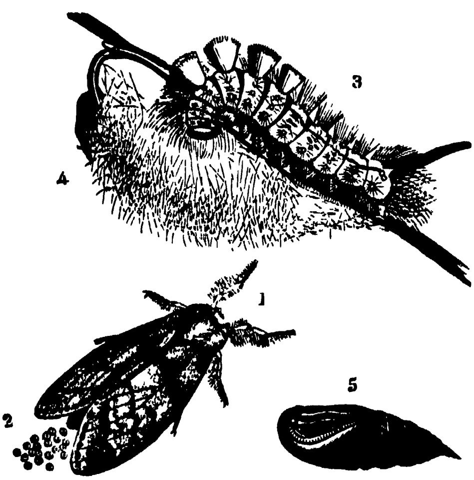
Dry summers are most favourable for the Dartmoor sheep-runs, for then the scanty herbage, consisting of lichens, moss, cotton grass, small fescues, and other minor plants, is particularly sweet. Foot rot, as in so many places, is a perennial trouble, but the Devon farmers find that if the knife is used judiciously, so that the disease may be reached at the bottom, and then the affected part is rubbed with powdered bluestone (sulphate of copper), a cure is generally effected.

Though the Dartmoor sheep has doubtless been much improved in recent years, there is abundant evidence that even a hundred years or more ago it was a sheep giving great fleeces of wool, and mutton of high quality. It then received considerable improvement by being crossed with the improved Leicester of Bakewell of Dishley's. Then the sheep was usually five years of age before fit for killing, and even at that age was of comparatively small weight; while now we have them mature much earlier, and at weights varying from 60 to 80 lb. the carcass. A flock of Dartmoor ewes is kept by the prison authorities on the land which has been so greatly improved and in many cases reclaimed by the labour of the convicts. In 1907 this flock, consisting of 144 ewes, raised 225 lambs, and in 1908 138 ewes brought 212 lambs. In 1907, 325 adult sheep and 225 lambs were shorn and yielded 5165 lb. of wool, of which about 700 lb. were credited to the lambs. As this wool was sold at an average price of 7½*d.* per lb., it would represent a total of £161, 8*s.*, or an average of nearly 6*s.* per sheep. The previous year the wool sold at 9½*d.* per lb. The above figures show that the sheep cut about 13 lb. of wool each, of the value of 8*s.*, and the lambs rather more than 3 lb. of wool each, worth 2*s.*

Dartmoor farmers usually 'dip' their sheep and lambs the end of July or early in August with the ordinary 'dip', containing sulphur, soft soap, and arsenic. To this is added some yellow ochre, which gives that colour to the sheep so commonly noticed by visitors when travelling through that district. Though the foregoing description represents the general characteristics of the best-known Dartmoor sheep, there is still another type found on some of the higher parts of the moor. This may be termed a rough, bony class, with white faces, and with tails left uncut. As these live on the rough, drier moor grass, and are not taken on to the richer grass and cultivated land of the vales, they do not

get dirty enough to necessitate their tails being shortened. The Scotch mountain sheep has also been introduced to these moors of Devonshire with some measure of success, but of course they will neither produce the quantity or quality of wool which is obtained from the breed of the district. Some of the most successful breeders of the true Dartmoor are: E. P. Northey, Bowden Farm, Okehampton; John R. Kingwell, Great Aish, South Brent; R. Luscombe, Wisdome Cornwood; and Messrs Ward and Chowen, Burnville, Tavistock. [E. Bl.]

Dasychira pudibunda (the Pale Tussock Moth) is greyish-white; the male has toothed horns, and the wings expand 2 in.; the female is ½ in. larger; the upper wings are freckled, with four irregular transverse darker lines, and a lunate or oval spot on the disk; also



Dasychira pudibunda (Pale Tussock Moth)
1, The female; 2, eggs, 3, 4, caterpillar and web, 5, pupa.

a row of black dots along the hinder margin; under wings nearly white, with a short stripe at the anal angle. The female lays in June a number of minute eggs, which produce caterpillars called hop-dogs; they are greenish-yellow, with four dense hairy tufts on the back, black stripes dividing the segments, and a long hairy rosy tail. They are very destructive in hop gardens; and when full grown, in September, spin a slight yellowish web, within which they change to brown pupæ. They also attack forest trees, being especially destructive to the Beech, and to a less extent to the Oak. The caterpillars should be collected and destroyed as they come down to pupate at the end of September, and the pupæ may be collected during the winter. As the eggs are generally laid low down on the trunks, grease banding is of some use, but the bands should be placed as high as possible. [J. C.] [C. W.]

Date Palm (*Phœnix dactylifera*) is a native of North Africa, Egypt, Arabia, Persia, Baluchistan, and perhaps also of the lower Indus basin. By cultivation it has been carried north to the latitude of southern Europe and west to America. It is the palm of the desert, and does not appear to have crossed the Equator to any appreciable extent. It is most successfully grown within a narrow belt of dry hot country, that may be spoken of as extending from Senegal eastward to Baluchistan and Sind, but is essentially an Arab production. A fairly extensive assortment of forms are recognized, mostly distinguished by the size, shape, and flavour of the fruit. Though known in Europe as a luxury, with many millions of people within the tropics it is an important article of daily food. It may be propagated by seed, and the better forms by offshoots found around the base of the stem. The plants are male and female, but since one male may suffice to fecundate many females, it is best raised from shoots, thereby the growth of a useless number of male trees being obviated. Without fecundation the fruits will not set. The flowering season is March to May, the fruiting, August to November. Rain during the former season lessens the chances of fecundation, and during the latter it sets up injurious fermentation in the fruit. Rain must accordingly fall from November to March, but to allow of a full crop, irrigation is imperatively necessary during the ripening season. The plants come into bearing in about seven to eight years from date of sowing, and may continue to yield crops up to 200 years.

Phœnix sylvestris is the sugar date, a smaller and less valuable tree, met with throughout the warm moist tracts of India, and is distinguished by the absence of shoots. The stem is tapped for its juice—palm toddy, which may be consumed fresh, or after being fermented, or even distilled into spirit (*arak*), or evaporated down to the crude sugar (*gūr*) very largely eaten in Bengal. [G. W.]

Daucus, a genus of the nat. ord. Umbelliferæ to which the Carrot belongs. See Carrot.

Davy, Sir Humphry.—This eminent man, who has been styled 'the father of English agricultural chemistry', was born at Penzance in 1778, his father being a woodcarver of considerable note in his own district. He was educated at local schools up to the age of fifteen, and two years later he was apprenticed to Mr. (afterwards Dr.) Beddoes, a surgeon in his native town. He soon developed a taste for scientific pursuits, much of his leisure time being occupied in chemical experiments. At the same time he made such good progress in his medical studies that when he was barely twenty years of age he was considered competent to take charge of the laboratory of an establishment which Dr. Beddoes had founded at Clifton under the name of the Pneumatic Institution, having been recommended to the position by Mr. Davies Gilbert, afterwards president of the Royal Society. Shortly afterwards Mr. Davy published an account of his researches on heat, light, and other subjects, including the existence of silica in plants. In the spring of 1801 he was appointed director of the Chemical Laboratory and assistant lecturer in chemistry at the Royal Institution, where he speedily attracted attention from the brilliancy of his lectures. In a short time he was made lecturer, instead of assistant lec-

turer, and in 1803 he was elected a Fellow of the Royal Society. In the same year he was appointed professor of chemical agriculture to the Board of Agriculture of the period, and for ten years he delivered courses of lectures for the Board. In 1813 the results of his agricultural researches were published in his famous work, The Elements of Agricultural Chemistry. The variety of Davy's researches was very great, and it would occupy too much space to give a bare list of the subjects upon which he threw light. One of his discoveries was that of the composition of the fixed alkalis. The famous safety lamp for miners, known by his name, was devised by him in 1815. Among the subjects treated in Davy's lectures were the structure of plants, soils and their analysis, the influence of the atmosphere on vegetables, manures, the burning of soils, fallowing, the rotation of crops, and food for animals. As an example of his perspicacity, it may be stated that he attributed to peas and beans the power of extracting nitrogen from the atmosphere. British and foreign distinctions were showered upon the great chemist From 1807 to 1812 he was secretary of the Royal Society. In 1812 Davy was knighted, and in 1818 he was made a baronet. In 1820 he became president of the Royal Society, a position which he held for seven years, after which ill health compelled him to resign He died at Geneva in 1829, at the early age of fifty-one. [W. E. B.]

Dead Fences. See FENCES.

Deadly Nightshade. See BELLADONNA

Dead-meat Trade.—The dead-meat trade, as we now understand the term, is the product of modern economic conditions, and of the application of science to the requirements of latter-day civilization. In a primitive state of society the animal required for food was brought alive into proximity with the consumer, and there killed and eaten. The preservation of meat for winter stores or for sea voyages was no doubt widely practised. The salting down or pickling of beef and bacon was one of the regular operations of the autumn in every village for centuries down to quite recent times, and during the winter ordinary folks lived largely, and at one time almost exclusively, on the meat thus stored. Salting, smoking, and drying were the means adopted for keeping meat, and by far the greatest of these was salting. The quantity of salt meat which our forefathers consumed would appal the more fastidious feeders of the present generation. An addition to these ancient methods of preserving meat was made when the 'canning' industry was established. This has been extended so that the meat-tin has become one of the significant signs of civilization, and the most remote places of the earth as well as the dust-heaps of the cities are disfigured by these forlorn relics of food.

But these methods of meat preservation are now little more than subsidiary adjuncts of the dead-meat trade in its modern phase. The refrigerator and the cold store are its true progenitors. So enormous has been the influence and so rapid the extension of the system of preserving meat by subjecting it to low temperature, that we have hardly yet grasped its full significance or realized the revolution which it has effected in the food supply of the world. The ingenuity of engineers and the application of capital have so far perfected the system of cold storage that the distance of the producer of meat from the consumer interposes no difficulty other than that of cost of transit, and meat killed in Argentina or New Zealand can be placed on the London market in practically the same condition as meat killed in Aberdeenshire or Norfolk. There is probably a subtle difference, which may affect its physiological value, between freshly killed meat and meat in which the natural process of decay has been artificially arrested, but assuming the original quality to be the same, the difference is not one which can be detected by the ordinary purchaser. Where the meat is actually frozen there is a difference in dietetic value which may be discovered by the consumer, but this practice (which belongs rather to the early stage of cold-storage development) is already largely falling into disuse, at any rate so far as the regular and immediate supply of the markets is concerned.

The total quantity of dead meat annually imported into the United Kingdom nearly approaches a million tons. Excluding rabbits, poultry, and game, we now consume about 48 lb. per head of meat killed in other countries. Forty years ago the quantity was only about 4 lb. per head. The total quantities of beef, mutton, and pigmeat imported have increased from a yearly average of 77,000 tons in 1861-5 to 870,000 tons in 1901-5 In the absence of equally precise figures for home production the exact proportion which this bears to the total consumption is a matter of estimate, but according to the best calculations available, it may be reckoned to represent not less than two-fifths of the national butcher's bill. The imports of live animals, which do not furnish more than 5 or 6 per cent of the total supply, may almost be regarded as unimportant in comparison.

The sources from whence dead meat is sent to this country are world-wide. Beef comes mainly from the United States, Argentina (which together send about nine-tenths of the whole), New Zealand, Australia, Uruguay, and Canada, with small contributions from Holland, Germany, and Denmark. Nearly half the mutton comes from New Zealand, and the remainder from Argentina, Australia, Holland, Uruguay, Chile, the United States, Denmark, France, and Belgium. Nearly half the bacon and two-thirds of the hams come from the United States, Denmark sending one-third of the bacon, and Canada more than one-fourth of the hams. Adding all three kinds of dead meat together, the following statement gives the quantities in tons imported in 1907 from each country sending more than 1000 tons:—

	Tons.		Tons.
Argentina ...	215,422	Russia ...	2,557
Belgium ...	2,442	United States	305,415
Chile .	1,375	Uruguay ..	6,768
Denmark ..	101,778	Australia ...	51,795
France . .	1,112	Canada ..	80,965
Holland ...	44,469	New Zealand	121,920

Altogether we received 682,873 tons from foreign countries, and 254,705 tons from the Colonies in 1907, the quantity from the United States being below the average, and that from Canada and New Zealand being above it.

To these vast contributions to the carnivorous demands of the British people must be added about 35,000 tons of rabbits, and an amount of poultry and game of which the total quantity is unknown, but the value of which exceeded a million sterling.

Those who believe that the proper dietetic destiny of man is vegetarianism will find little to encourage them in these facts; but they may, so far as their theories are based on humanitarian considerations, rejoice that the development of the dead-meat trade tends to diminish the sum of animal misery by reducing the suffering caused by driving or conveying animals long distances before slaughter. [R. H. R.]

Dead-nettle (Lamium), a name given to weeds belonging to the nat. ord. Labiatæ. They are readily distinguished from stinging nettles by the absence of the stinging hairs, and by the presence of conspicuous flowers Three species occur as weeds: Purple Dead-nettle (*Lamium purpureum*), Henbit Dead-nettle (*Lamium amplexicaule*), White Dead-nettle (*Lamium album*).

1. *Purple or Red Dead-nettle* is a very common annual weed of cultivated and waste ground which may be found in flower all the year round. It is marked by the purple corolla of its flower, by the purple-tinted heart-shaped leaves with rounded teeth on the margins, and by the aggregation of these leaves towards the apex of the stem—so close is the aggregation that the middle part of the stem is left bare. Good tillage is effectual for eradicating this weed.

2. *Henbit Dead-nettle* is another annual weed, frequent in cornfields and gardens wherever the land is sandy. It is marked by the deep rose colour of the flower, and on the upper leaves by the absence of a leaf-stalk. For eradication, good tillage again suffices.

3. *White Dead-nettle* is a somewhat coarse, hairy perennial, with the underground stems short and creeping, and the air stems about 1 ft. high. This species occurs chiefly on waste land, and is readily recognized by the pure-white corolla of its flower. [A. N. M'A.]

Dead's Part. See SUCCESSION.

Death Duties. See SUCCESSION.

Death's-head Moth. See ACHERONTIA.

Death-watch. See ANOBIUM.

Debility. — By debility we mean lowered vital forces, or weakness of a general character, inviting disease, if not caused by it. It is common to find animals that have lain out during the winter in a state of debility before the summer grass recuperates their strength and enables them to store fat for winter resistance to climatic conditions. The debility that follows on certain diseases, as influenza and strangles, and difficult or prolonged parturition, is of more serious import often than the malady itself. Especially is this the case where a blood dyscrasia is set up, and the red corpuscles are attacked and broken up, as in red water in cattle, and purpura hæmorrhagica in horses. The symptoms of debility are pallor of the mucous membranes, a small or feeble pulse (see PULSE), shortness of breath, sweating upon very slight exertion. As a rule, the debilitated animal is low in flesh, but this will not be the case where a fat animal has been debilitated by an acute disease of short duration. *Treatment* consists in providing good hygienic conditions, pure air being very important, suitable food, water, and clothing, and the administration of tonics of both vegetable and mineral origin, with mineral acids in dilute form (see TONICS). [H. L.]

Decay is the process during which a body becomes broken up and disintegrated by the action of external forces. The term is generally used to indicate organic decay or the breaking up of a living or once living body, as distinct from the oxidation of metals or the disintegration of rocks under the action of weathering (compare SOIL, FORMATION OF). So long as an animal or plant is alive it is able to resist the attacks of other living organisms as well as chemical or physical action, but in passing from vigorous life to a weaker condition there comes a stage when external forces become the stronger, then decay sets in. Dead tissues can only be preserved from decay by preventing the action of external agents. A plant or animal generally consists of some dead as well as living cells, but under normal conditions dead cells, such as those of external layers like the epidermis, are specially adapted to resist decay and also to protect all enclosed tissues. If a ripe apple or potato is cut, the exposed surfaces soon become discoloured through chemical changes following exposure. Putrefactive decay is brought about by the action of animals, such as insect larvæ, or by low plant-forms, such as bacteria, yeasts, and fungi. These agents promote many changes, which transform the materials of the dead body into other forms of matter. Thus a green plant, the foodmaker for all animals and non-green plants, builds up a complex body from carbon dioxide, water, and mineral salts; sooner or later the plant dies and a new series of substances is formed from its putrefactive decay. Enzymes and fermentation play a great part in this work (see arts. ENZYME, FERMENTATION, BACTERIA, FUNGI, &c.). The products are innumerable, some useless, some injurious, some useful (see NITRIFICATION, DENITRIFICATION, HUMUS, &c.). The final result is that the dead bodies disappear and no longer cumber the earth.

Disease frequently precedes decay, and is in many ways a special form of it. Age, injury, and unsuitable nutrition or surroundings may weaken a living organism or some part of it, so that other organisms are in a position to attack it; disease occurs, followed by local or general death and decay. Wounds, since they include dead and diseased tissues, are a common starting-point for decay; see references in articles on many insects and gnawing animals, and under parasitic fungi, like those on Apple, Larch, Pine, &c. Unsuitable conditions also promote disease, as well as favour the growth of the organisms

of decay. See TURNIP, FINGER-AND-TOE, CLOVER SICKNESS, POTATO DISEASE, DAMPING OFF, and other articles on parasitic fungi. [W. G. S.]

December, Calendar of Farm Operations for.—

1. SOUTHERN BRITAIN

TILLAGE OPERATIONS.—*Crops.*—Ploughing up stubbles in preparation for spring crops still continues, but it is not desirable to plough in bad weather. Ploughing should be kept close up behind the sheepfolds. Lea ploughing may be commenced. Wheat and winter cereal crops may still be drilled in during this month if the weather suits, but should have been got in sooner if possible.

Grass Lands.—Harrowing to prevent growth of moss, and levelling molehills on pastures and meadows, take place during this month. Young stock get the general run of the pastures.

Roots.—The land for next season's crop of mangolds and kohlrabi and other roots is being got ready now by dunging, ploughing, and ridging up.

Some kohlrabi, swedes, and turnips are still on the fields, and are being carted off as required, or they are being folded with sheep.

Manuring—In frosty weather, farmyard manure may be carted on to the fields.

Marl, clay, and lime are carted and spread.

Basic slag can still be applied broadcast on the pastures during this month.

STOCK.—*Horses.*—Horse labour during this month consists chiefly of carting produce off the farm, and feeding-stuffs, manure, &c., on to it. Field work, excepting ploughing, is generally at a standstill, therefore the horses' work is practically at a minimum. These are fed on ordinary rations, not being allowed too much when idle, but are not allowed to fall away in condition, as their busiest time will soon come round.

Cows.—On farms where cheesemaking is the industry, the cows will be all dry. They are housed at night and during the greater part of the day. They are kept warm and comfortable in the house, and fed on mangolds, turnips, kohlrabi, chaff, 'grains', hay, straw, and cake, with a little salt to give relish to their rations. Cows in milk for the new milk trade require as much forcing food as possible on account of the difficulty of keeping up the milk yield at this time of the year; when 'dry', their feeding should be much reduced, and they may be turned outside altogether.

Young stock have been in their winter quarters for over a month now, and everything should be going on regularly. If they are not improving as they should be, a little extra cake should be allowed them. It is a good plan to keep a lump of rock salt where they can get licking it.

Store cattle are mostly pastured in outlying fields, unless the weather is exceptionally severe.

They are visited as often as possible, and the waterholes kept clear of ice. A little hay or straw is now fed to them at the back of a hedge if necessary, as they are unable to pick up a very good living from the pastures.

Fattening Stock.—This is the chief month of the year for fat-stock shows and sales. Animals intended for exhibition are carefully groomed and got up now. They are fed on much the same rations as dairy cows, but with large quantities of linseed cake, and during this month should be very highly fed to put on the final 'finish' for the Christmas fat-stock markets.

Sheep.—Ewes in lamb should be allowed plenty of exercise.

The lambing yard should be got ready. The ewes should be allowed a small quantity of cake to keep up their condition, but not to get fat for lambing.

Poultry.—The fattening of birds for Christmas market is finished during this month by some final 'cramming'.

Pigs.—Pigs are the most sensitive of farm stock to cold weather, so it is necessary to feed as little cold food as possible, and allow plenty of warm bedding. [P. M'C.]

2. NORTHERN BRITAIN

WHEAT SOWING.—On farms where wheat is sown, the most pressing work will be the finish up of any arrears of this work still to do. Where it can be avoided, all wheat should be sown before December, but in a wet autumn it sometimes happens that this cannot be done. On light land the delay is not a very serious matter, but where the land is heavy, if wheat is not sown before the opening days of this month, it is better delayed till February. Seed sown in December lies a long time in the ground before any growth appears, and in the interval much of it dies, or is consumed by vermin of one kind or another. For these reasons, wheat sown in December should receive 25 per cent more seed than if the work was done in September or October.

ROOTS.—All turnips which it is intended to cart to the farm should be brought in at every favourable opportunity. If it is intended to store these in the field, such work should also be hurried on, and where they are wanted to be so stored that they can be available at any time, few better methods exist than small heaps of a cartload or so, in regular rows over the field. These should be neatly built up, and if well covered with soil, a sound crop will have little waste until far on in the spring. For very late use, the best method is 'sheuching'. In carrying it out, two rows of turnips are pulled up and set closely together in the bottom of the drill, a plough furrow being afterwards thrown over the bulbs from each side, the tops as far as possible being allowed to remain above the soil. So covered, turnips usually keep well in any ordinary season till the grass comes.

PLOUGHING.—All stubble land should be ploughed as early in the month as weather and other circumstances will permit. If there is any of this which is polluted with root weeds of any kind, no attempt should be made to kill these by ploughing them deeply down, as such never succeeds. Such land is better to be ploughed as thin as possible, say 3 or 4 in. deep. These weeds are usually shallow-rooted, and they are much easier shaken out of 3 in. of soil than out

of 9 or 10. As soon as the stubble ploughing is finished, or when the weather is wet, lea ploughing may be proceeded with, and, if possible, should be about half finished by the end of the month.

STOCK.—In mild weather, stock of all kinds should be allowed to have a short time in the fields, more particularly if the land is dry underneath. If wet or clayey, while the outing will do the stock some good, the feet of the cattle will do the land more harm than they are benefited by being out. All stock should now be in their winter quarters and on winter rations, but although partially or wholly confined to the house they should not be deprived of fresh air. If the buildings be kept well ventilated at the beginning of winter, the stock will keep on their winter hair, and when more severe weather comes they will suffer little or no inconvenience. Feeding sheep on rape or roots should be sold when they are ready, or as opportunity occurs, and grain and potatoes should be marketed from now forward. On most farms carrying a big head of cattle, and where grain is largely grown, thrashing has to be prosecuted vigorously to provide fodder for the stock. [J. S.]

December, Calendar of Garden Operations for.—

1. SOUTHERN BRITAIN

The most important work in the kitchen and fruit garden is the preparation of the ground and the planting of trees and bushes, for although these operations may be commenced after October, they may be continued throughout the winter whenever the weather is favourable When the ground is frostbound, manure can be carted or wheeled over it and placed in readiness for use when digging. In open weather, trenching should be proceeded with What is known as root pruning for fruit trees, that is opening a trench all round them and cutting away strong roots, can now be best performed. Pears, apples, plums, and cherries are sometimes improved by this treatment, and, in the case of small trees, transplanting is sometimes advisable with a view to bringing them into bearing quickly. It is not advisable to perform such operations as these when the soil is heavy with moisture. Freshly planted trees should at once be supported with stout stakes. Pruning may be done at any time after the fall of the leaf, and when other work is stopped by frost. Such trees as apricots, apples, cherries, nectarines, peaches, pears, plums may be advantageously pruned. Raspberries may be thinned and staked, but gooseberries and currants may be left a few weeks longer on account of birds. Spraying for the destruction of fungoid and insect pests, or as a preventive, may be commenced in this month. For directions as to spraying mixtures, see art. on SPRAYING. All garden refuse, prunings in particular, should be collected together and burnt on the ground. This is preferable to placing them on the rot heap to be afterwards used as manure, as disease is often spread in this way. Artichokes may be prepared and protected, and asparagus beds cleared and dressed with well-rotted farmyard manure. Cabbages will require hoeing. Broccoli that are forming heads should have the inner leaves broken to afford protection. Celery still in the ground should be protected from frost by covering it with mats, straw, bracken, or boards. Lettuce in frames will require daily attention, the lights being removed in favourable weather, while during severe frost a covering of some kind should be provided. Endive may be lifted and put into frames to be blanched. Mushroom beds under cover may be prepared and spawned. A sowing of radishes in a frame may be made. Rhubarb roots for forcing may be lifted and placed in a warm, dark place, such as under the stage in a greenhouse, or in a little soil inside a frame placed on a bed of straw manure. Sea-kale for an early supply may be started in a warm frame. Where early grapes are grown the temperature of the house, started last month, may now be raised to 65° by day and 55° by night. Peaches and nectarines grown under glass should be kept well ventilated, and the temperature at a minimum of 50°, syringeing them freely on sunny days.

Where there are greenhouses it is important that they should be kept well ventilated, much harm being done to plants in winter by keeping the houses close and overheated. Sunlight and heat should be made the most of, and it is surprising how much can be done in this direction to keep down fuel expenses. Plants in pits and frames will require all the light possible, and plenty of ventilation; remove the 'lights' whenever the air is mild. Such plants as carnations, calceolarias, stocks, azaleas, and camellias are frequently ruined by coddling in winter. Trees and shrubs in the open borders may receive attention, such operations as pruning, thinning, transplanting, and training being performed whenever the weather is favourable. Alterations which involve much labour are better begun early in November, but they may proceed throughout the winter, providing the soil, &c., are in suitable condition. [W. W.]

2. NORTHERN BRITAIN

When the weather is favourable and the soil in suitable condition, make good any arrears in the planting of deciduous trees and bushes—this particularly refers to garden fruits. On no account should the planting of these be done in wet weather or when the soil is cold, clammy, and sodden. If these conditions exist, defer the planting until early spring. In frosty weather the pruning and training of fruit trees and bushes should be attended to. See that all prunings are raked up daily before dusk, as it is bad practice to allow the prunings to lie and be frozen into the soil. The wheeling of manure on to the garden quarters should likewise be done when the surface of the ground is hard and dry.

In open weather push on the trenching or rough digging of the vegetable quarters. Remove all decaying leaves from the winter vegetables to prevent rotting in the plants. If Broccoli has made a too luxuriant growth, the plants should be checked by taking a spadeful of earth from the north side of the

plants and pressing them over to an angle of 45 degrees. If carefully done, this simple plan is usually efficacious. Late celery, if not earthed up before, should have attention ere hard frosts set in. Provision should also be made for the protection of the tops of celery and other vegetables in hard frosty weather. Probably the best protecting material for this purpose is dried brackens; failing such, clean wheat straw is good. If protection is found necessary, a light covering will suffice. Advantage should be taken in weather unfavourable for outdoor work to examine the fruit and vegetable stores and remove any decaying specimens. Keep the stores at a steady low temperature and free from light and draughts. The secret of the successful preservation of fruits and roots is the avoidance of high temperatures and drying currents of air. In the hardy flower borders the Christmas Rose (*Helleborus niger*) and its varieties will be coming into bloom. In most districts the purity of the flowers will be enhanced by covering the plants with a handlight; the pattern which has a movable top is preferable, as it admits of more freedom for examination and air. Keep a watchful eye on any rare or doubtfully hardy plant, and protect from weather and slugs. The timeous protection of the exposed crowns or stems of many plants by some light unobtrusive material, such as sifted ashes, leaf mould, coco fibre, or even sawdust, will not only save the plants, but vexatious heartburnings in spring.

Admit air to plants in cold frames night and day when the weather is open and fresh, but during the prevalence of frost or drying winds keep the frames closed and protected.

If early rhubarb is desired, lift good strong stools and place them in heat, keeping them close and dark. Where special appliances are not available, rhubarb and sea-kale can be forced on a hotbed made of stable litter mixed with leaves. Allow the hotbed to settle for a day or two, then place on it a deep, strong, rough wood frame, in which place the stools, filling the interstices with light soil or leaf mould; keep dark, close, and warm, and good stalks should be available in from four to six weeks. Lily of the Valley can be forced, and several other plants, such as tulips and hyacinths, advanced under similar conditions; but these must be hardened off carefully, and gradually exposed to light to produce good results. It is well to note that many plants force more readily if subjected to a low temperature before being placed in the forcing house, and of these the Lily of the Valley is the most notable. This does not apply, however, to bulbous plants as a rule, so care and discrimination are necessary in the matter of early forcing. [J. WH.]

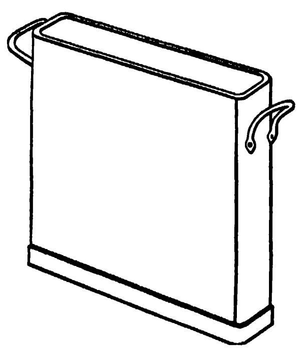
Decorticated Cotton Cake. See COTTON CAKES.

Decoy

Decoy.—A decoy is a long curved channel covered by netting, opening out of a sheet of water, and is used for the purpose of catching ducks, especially in fenny districts. At its opening it is about 27 ft. wide, and as it gets farther from the lake it gradually narrows, till it terminates in a point. It is constructed so as to curve gradually to the right or left, in such a way that a duck near the opening of the channel can see only a short way up. Hoops of wood or iron are set up over the channel at frequent intervals, and are covered over by strong netting, so that a tunnel, or, as it is usually called, a 'pipe', is formed, from which there is no escape save by the entrance from the lake. The height of the pipe at its mouth is about 15 ft., but this

gradually diminishes until, at the extreme end, the pipe ends blindly in a sort of pouch. Along the convex side of the pipe a series of screens is arranged in echelon fashion, in such a way that a man standing behind any of them can see up the pipe, but is hidden from the main sheet of water. Operations are commenced by the decoy-man taking up his position behind the first screen, and throwing over some handfuls of grain into the mouth of the pipe. Decoy ducks, kept for the purpose, immediately swim up to feed on the grain, and presently wild ducks are attracted also. When the birds are at the mouth of the pipe they are enticed up by means of a small fox-coloured dog, which is trained to dodge in and out of the screens along the side of the pipe. Curiosity makes the ducks follow the dog, and when they are a little way up, the decoyman can show himself and drive them up to the end, where he takes them out and wrings their necks. To ensure success, the wind should be blowing down the pipe towards the lake; and for this reason several pipes should be constructed, opening out of different parts of the lake, and curving in different directions. [H. S. R. E.]

Deep-setting of Milk.—During a period of twenty years or so, before the coming of the



Swartz Can

'separator', or at all events before it was at all in general use, deep-setting of milk in ice water for cream raising became most popular in northern Germany, in western Russia, in Denmark, Sweden, Norway, Finland, and elsewhere around the Baltic sea. The storing in winter of an ample supply of ice for use in summer was always a feasible piece of work, and it was on ice that the whole thing depended in the hot weather experienced in some of those countries during the summer solstice. During the rest of the year, if only good spring water was at hand, ice was not required for deep-setting of milk. The water must be down at 42° to 45° F., or else ice is wanted.

Flat-sided, round-ended cans, 24 in. deep by 16 in. long and 6 in. wide, made of strong steel plate, tinned, and having loose lids with small ventilators, contained milk up to within some 2 in. of the top. A greater or lesser number of these cans, made in sizes to contain up to 3 or 4 gal., but always of one uniform size for each individual dairy or group of dairies, when filled were lifted into a long wooden tank about 18 in. or 20 in. wide, and some 24 in. or 26 in. deep, containing a quantity of cold or ice water. The water rose up as high as the milk in the cans, and none of the cans touched each other. The water, in fact, encircled the cans. The cream rose to the surface in twelve to eighteen hours.

Here again the separator, that wizard of the north, came forth to disendow the once famous deep-setting system of cream raising, which was called the 'Swartz system' in honour of the highly intelligent Swedish farmer and landowner who invented it. [J. P. S.]

Deer. See FALLOW DEER, RED DEER, CARIBOU, also succeeding arts.

Deer Forests in Scotland.—The expression 'forest' is apt to be misunderstood by English readers. A deer forest does not imply a tract of country covered with wood; trees are undoubtedly advantageous to a certain extent as winter shelter for the deer, and many forests have large wooded belts or clumps, but the ground as a rule is bare of wood. Generally, deer forests are high lying and mountainous, and quite unfit for profitable cultivation. A great extent of many forests consists of little more than rock, partly covered with heather; only in the better class does one look for grassy flats, so essential to the rearing of good stags.

The number of deer forests is difficult to fix with absolute precision. The transition from grouse moor to deer forest is so indefinite that it can scarcely be said where the one ends and the other begins. It may, however, be held that the number is about one hundred and fifty, and the extent three and a half million acres. Two House of Commons returns, one for 'crofting', the other for 'non-crofting' counties, give the following figures.—

	Acres.
'Crofting' counties—Argyll, Caithness, Inverness, Ross and Cromarty, and Sutherland	2,920,097
'Non-crofting' counties — Aberdeen, Banff, Bute, Dumbarton, Forfar, and Perth	548,300
Total	3,468,397

These returns are imperfect, but the totals may be accepted as practically accurate. The six largest forests are Mar (the Duke of Fife), 87,000 ac.; Blackmount (Marquis of Breadalbane), 80,000 ac.; Strathconan (Captain Combe), 59,000 ac.; Corrour (Sir John Stirling Maxwell, Bart.), 56,251 ac.; Reay (the Duke of Sutherland), 56,037 ac.; and Letterewe (the Marquis of Zetland), 52,009 ac.

While the average rental is under 1s. per ac., some curious facts are revealed in the parliamentary returns. The highest rent paid is that by the tenant of Glenfeshie (Inverness-shire), £4628 for 41,499 ac.; yet Blackmount, nearly double the size, is entered at only £1930. The King's forest of Balmoral (16,000 ac.) is returned at £750, but as tenant of the contiguous forest of Abergeldie (12,000 ac.), His Majesty is charged on £1227 additional. Strathconan is assessed on £2400; Invermark, in Forfarshire (the Earl of Dalhousie), a forest of 40,000 ac., pays on

£3830. The value of a deer forest is materially increased by good driving roads and pony paths. The ground must also be drained and the heather regularly and systematically burned. In old times it was never held that bare hills were sufficient for red deer all the year round. In the heat of summer and autumn, stags naturally take to the mountain tops; in severe winters low ground is required as much for food as for shelter. It is quite impossible for deer to remain for any length of time on hills which may be covered with a uniform depth of several feet of snow for three (or more) months in the year. If their own forest is devoid of shelter they wander to others till they find themselves comfortable—hence one reason for the great differences in the value of forests.

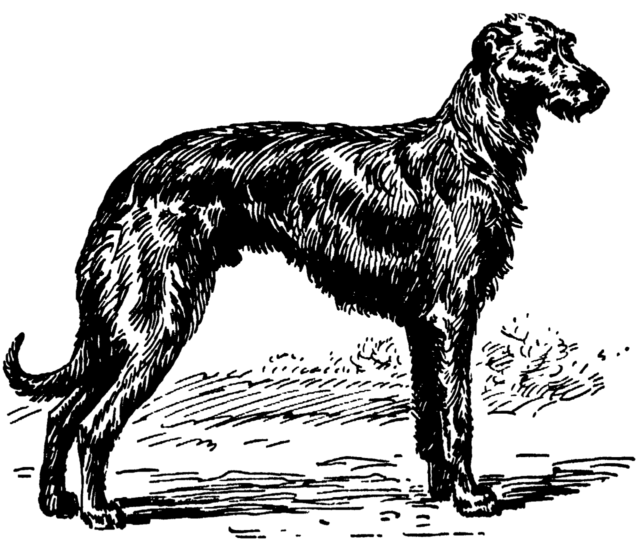
The value is also partly determined by the number of stags a forest can sustain throughout the winter. Nature is often supplemented by a supply of Indian corn, locust beans, and hay. Judicious artificial feeding is an important element in management, though some specially favoured forests need never resort to it; certain owners abstain, probably to their own loss and to the expense of their neighbours, from in any circumstances thus assisting the deer. Hand-feeding is indeed not always an unmixed benefit; deer often become demoralized by it, and, long after they should be out on the hill in search of natural food, they will hang about the stalker's cottage for the dole to which they have become too accustomed. It is the stag who has to be 'nursed' through winter and early spring owing to his poor condition after the rut; the hind, on the other hand, is in her best form, and accordingly able to withstand the privations due to long-continued snow and rain. After a severe winter, however, the hinds, especially those in calf, will be much benefited by a little hand-feeding—a fact which is by no means properly realized in not a few forests.

The weight of the stag is an indication of the nature of the forest, but even more so the number of points and the quality of horn. The goal of all management, after the primary requirement of a sufficiently large annual bag, is weight and horn, particularly horn. A yearly return of a 'warrantable' stag per 500 acres is often looked upon as very satisfactory, but this is a matter of individual forests. Three hundred acres, and even less, sometimes yield a good stag; in other districts 600 will not be sufficient. As there is a well-defined limit to the grazing capacity of a field, it is quite absurd—as well as most injurious to the forest—to offer a tenant a 'limit' of say fifty stags where, even with the best management, only thirty-five should be killed.

There is too often a desire on the part of the sportsman to shoot only the best 'heads', but the forest should be judiciously cleared of all 'poor' stags so as to prevent a gradual deterioration of the stock. Hinds also, while they ought not to be allowed to become too numerous, should be killed with discrimination; in the anxiety for good venison in winter the eild hinds are too often sacrificed. In well-managed forests, however, old toothless animals, and 'backgoing' beasts generally, receive the stalker's attention, for such are only cumberers of the ground.

[T. W. C.]

Deerhound.—It speaks well for the attractiveness of the Deerhound that the variety should continue to hold so high a position in the estimation of the public, though the sphere of its utility has been considerably decreased.



Deerhound.

The Deerhound, the largest and probably the most important, as it is the most picturesque, of all the canine varieties bred north of the Tweed, has always maintained a reputation amongst sportsmen as a most valuable hound, and it is owing to no fault of its own that its services are not in so much request as formerly. Large numbers of them are, however, still utilized in the deer forests of Scotland for the purposes of holding up wounded stags; but in the old days many years ago, when deer were more abundant and their destruction more general than now, the services of the breed under consideration were naturally more in request than at present.

The antiquity of the Deerhound is undeniable, as the breed has been associated with Scotland in some form or another almost from time immemorial, a fact that renders the task of attempting to trace its genealogy to its taproot extremely difficult. It is surmised by some that the now extinct Irish Wolfhound was either an analogous variety or else a remote ancestor of the Scottish Deerhound, and unquestionably the

two breeds — that is to say, if reports speak *truthfully concerning* the points of the Irish breed—possess many characteristics in unison. Whether a common origin or a close affinity of blood was shared by the Wolfhound and the Deerhound, the fact remains beyond all question that when a small band of enthusiasts determined to resuscitate the Irish variety a few years ago, the Deerhound was the variety selected to impart the correct formation to the results of the experiments which were being made. All this, however, is rather outside the scope of the present article, but the fact may be referred to as assisting to show that the Deerhound is accepted as being a variety of hound which is sufficiently established to enable it to transfer its main characteristics to its cross-bred offspring, and moreover to perpetuate them subsequently.

Although the Deerhound still occupies a deservedly high position as a picturesque and popular member of the canine world, it must be candidly admitted that the attention bestowed upon such comparatively modern creations as the Great Dane, St. Bernard, and Irish Wolfhound, has affected his popularity considerably, as there are not a very large number of breeders who can maintain a kennel of big dogs, the result being that all the heavier breeds have suffered from the effects of competition between themselves. The Deerhound, however, possesses the advantage of being essentially a companionable as well as a useful variety, and consequently, in cases where his owner possesses no use for his services for field purposes, he is appreciated for his sociability as much as for his picturesque appearance. It is not surprising, therefore, that the breed has held its own in the face of competition as well as it has, for though its courage is beyond all question, the Deerhound will always rank high amongst the larger varieties of dogs, if only on account of its docility and the affection it displays towards its master and the members of his family.

The skull of the Deerhound is long and narrow, rather flat on the top, and tapering gradually towards the nose, which should be large, with well-developed nostrils. The muzzle is also long and extremely powerful, any tendency towards weakness of the jaw being a decided fault, whilst the teeth are long and regular. The eyes of this breed are somewhat peculiar, for, although small and rather bright, they possess a very mild and affectionate expression, which is not usually associated with small eyes, and they should be dark in colour, hazel being more common than brown. The ears should be small in size and delicate in texture, and carried close to the skull, though they can be raised when something particular attracts the notice of the hound. The neck, though long, is extremely powerful, but this fact does not in any way detract from its elegance, and a short heavy neck may be accepted as a serious fault, for it would detract greatly from the activity of the hound, and hence diminish its possessor's power when engaged with a wounded stag. The shoulders must slope, as otherwise the speed of the breed would be reduced, which would be a serious defect in the case of a hound whose work it is to follow up deer, whilst the chest for the same reason should be narrow, though this is compensated for by its extreme depth; indeed there are few varieties which are more let down behind the forearms than the Deerhound. The back is arched at the loins, and the back ribs are rather short, as is often the case of breeds whose forte is excessive speed, such as the Greyhound. The front legs are somewhat long, but their bone and substance being great, their length is not so very apparent as it would be otherwise, and they must be perfectly straight and not inclined to turn out at the shoulder to the slightest extent. The quarters are very muscular and powerful, and the hind legs well let down towards the ground, well bent at the stifles, and with a good distance between these joints and the hocks. The tail is long and is carried low, excepting when the animal is excited, and the coat, excepting on the head, where it is rather silky, should be profuse, coarse, and weather-resisting. As regards colour, the most common ones are steel-grey and brindle, but fawns are often seen; the average weight being from 100 lb. in dogs to 70 lb. in bitches, whilst about 30 in. is the average height. [V. S.]

Deer's-hair Grass. See SCIRPUS.

Deerstalking.—Deerstalking is a combat of wits between the sportsman and the stag, where the conditions are not altogether unequal. Though the stalker is armed with telescope and rifle, the stag on the other hand has apparently an abnormal faculty of scent and keen eyesight, while in mobility there is absolutely no comparison between hunter and hunted. The use of staghounds is now a thing of the past, so that no small part of the picturesqueness of the chase has become lost. One of the great defences of deer, their extreme timidity of man, has still to be reckoned with. A close approach is exceedingly difficult, and herein lies one of the great charms of stalking, for not only are the difficulties already named to be overcome, but there are sentinels to be dodged or deceived. Look at a herd of deer; rarely will they be found with their heads all in one direction—not only so, but there will be certain members, generally old hinds, who are ever on the *qui vive* on outpost duty. Deer seldom enquire as to the causes of alarm, generally bolting at the first suggestion of danger, and only halt for a moment, after they have galloped some distance, to try and ascertain what has startled them.

Deerstalking has been called the sport of kings from time immemorial, and still continues to rank first in this country. It is of necessity the sport of the few; men do not go into a forest in the same numbers as they enter on a grouse moor. A salmon river permits of more rods on its banks than even the biggest forest has room for rifles. A gunner would feel disgraced to return with an empty bag, and seldom goes out without firing off a few dozen cartridges. The stalker on the other hand is content if he gets one bullet sent home. Indeed he may often return to the lodge without having let off his rifle, and in this glorious uncertainty we have half the fascination of 'the game'. Extreme

fatigue and crawling on one's stomach over rough and wet ground are only some of the incidents inseparable from the pursuit of the stag. One's patience is often sorely tried in immovably waiting, it may be for several hours, for a stag to change his ground or position; but all must be undergone in absolute silence. One stag is considered a very successful result, two or more mark memorable days.

The direction of wind is the prime factor in deerstalking; unless stags are approached against the wind, success is impossible. Under the best atmospheric conditions in favour of deer, they can scent a man at the long distance of a mile and a half. They have been known to refuse to cross a man's track even more than four hours after he had passed; then if following a daring leader they will jump across it, evidently thinking that thereby they escape some hidden danger.

Under certain conditions one may risk a whiff of 'down' wind, say in stalking from higher ground than where the deer are, in which case the scent is blown over them and the sportsman scores. Stalkers prefer a moderately strong wind as being less liable to shift than uncertain light breezes. Deer delight in a position where not only they can have a good outlook, but where two winds from different directions can blow upon them—a common enough occurrence in many corries, due to the formation of the ground.

It is given to few to successfully stalk stags without the help of a professional. Life is too short for the ordinary sportsman to acquire that intimate knowledge of a large forest and of the habits of deer so essential to a successful day on the hill. It has been well said that while a man may learn any trade or profession, and even become an expert in it, yet as a deerstalker he must be to the manner born, and even then rarely becomes the perfect artist. Stags are very apt to become suspicious, and they will rather face the dangers they see than advance to unknown risks. A sudden change of wind has utterly spoiled many an elaborately arranged stalk, and sent back the rifle without firing a single cartridge. A careless stalk may quite clear one's own ground, to the benefit, of course, of the adjoining forests. So innumerable and often unaccountable are the surprises which deer have in store for their pursuers, that men after half a century's experience as stalkers are still ready to admit they have something to learn. The stalker who is too cautious is as useless as he who is too rash; the ideal temperament is a happy mixture of dash and reserve.

Long shots in deer forests are only for good marksmen, and even then should not be encouraged. Though the rifle may be in capable hands, circumstances seldom warrant attempts at over 200 yards. The stag presents a very small target, and should be shot in the heart; haunching, by the etiquette of the forest, may almost be considered a crime. As for wounding a beast (should that unfortunately happen), allowing it to escape, perhaps to die a lingering death or be left a cripple, that must be avoided at all costs. The neck is a fatal spot, but then deer have very small necks; with a broken leg, or a wound in the stomach, deer will run for miles and outdistance the stalkers. In such cases it is not advisable to follow up at once, but rather lie concealed, the odds being that the beast will probably lie down and stiffen. 'Stag fever' is not confined to novices; even old hands at the commencement of a season may doubt their powers, and, doubting, fail to score. In the old days, before rifles were brought to such perfection, more stags were killed at under 80 yd. than over that distance; with the modern weapons there is little excuse for a miss at even a longer range. These rifles have not only lessened disturbance in the forest—where silence is a virtue—but have considerably improved shooting.

The stalking season is very short, so the best has to be made of it. It opens when the stags are free of velvet—that may be late in August, or even in the beginning of September; it closes when the rut commences, say in the first or second week of October. There are no legal dates. [T. W. C.]

Degeneration, a term used somewhat loosely to denote a retrogressive structural change in the body of a plant or an animal. In the course of this change there is a reversal of the progressive differentiation which is characteristic of ordinary development. It is necessary to distinguish various processes to which the term 'degeneration' may be applied. (*a*) In some animals, notably in those which are domesticated, there may be degeneration in particular organs as age increases. It is unusual for wild animals to show more than slight hints of senescence, partly because the natural conditions of their life are so healthful, and partly because the struggle for existence eliminates both young and old when they show any signs of weakness. But in domestic animals it is common to find in brain and eyes, in heart and arteries, in kidneys and reproductive organs, instances of that senile involution or degeneration which is so conspicuous in man. (*b*) In the life-history of various animals there are degenerative processes which last for a time and are normally recovered from. Thus when the maggot of a bluebottle passes into its pupa stage there is a very remarkable degeneration of its organs. There is a return to a state of simplicity like that of a young embryo, yet out of this degeneracy the new complexity of the adult insect arises. (*c*) Degeneration sometimes occurs when an organ is not used or when its normal function is interfered with. A muscle which is not exercised becomes soft and smaller, but there is no evidence that the number of muscle fibres is reduced, or that the effects of the disuse are transmissible. Degenerative changes occur in the ovary of trout and other fishes when no opportunity is afforded for egg-laying, and there are many similar cases. (*d*) Degeneration is often seen in the life-history of parasites, especially when the young forms are free-living and the adults are parasitic. (*e*) Finally, degeneration may be induced by disease or by malnutrition and the like.

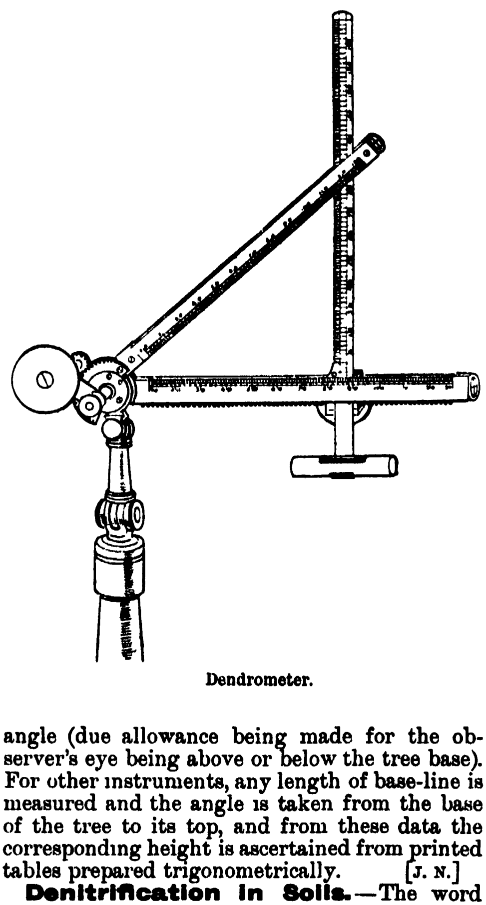
It is confusing to apply the term to cases of arrested development, or to reversions, or to

the disappointing results of crossbreeding. The word has quite enough to bear as it is. Moreover, it seems wiser to keep the term 'degeneration' for cases where the process is observable in the individual. When we say that a type is degenerate in comparison with a presumed ancestor of higher standing we are introducing a new idea, namely that of gradual racial adaptation to simplified or altered conditions. Even in regard to individual degeneration it must always be noted that the process *may* result in a more effective adaptation to a peculiar, *e.g.* parasitic, mode of life. [J. A. T.]

Delphinium (Larkspur), a large genus of herbaceous annuals and perennials (order Ranunculaceæ), many of the species being cultivated in gardens. The best of them are: *D. cardinale*, bright-scarlet; *D. cashmirianum*, pale-blue; *D. grandiflorum*, dark-blue; *D. nudicaule*, bright-red; *D. Zalil*, yellow. The annual Larkspurs or Rockets are *D. Ajacis*, of which there are many beautiful varieties, and *D. consolida*. Seeds of these should be sown in the open air in October to flower the following July. The most popular, however, is the race which has been bred by crossing several of the species, including *D. grandiflorum* and *D. formosum*. This race comprises plants of high stature and robust free-flowering habit, and in the months of June, July, and August they form really splendid objects, either in the herbaceous border, or planted alone in a large bed in a conspicuous place in the garden. They are perennial, will grow freely in any garden soil, may be propagated by division or from seeds, and they are hardy even in the most exposed situations. [W. W.]

Demodex, a genus of minute, wormlike mites (Acari) which live in the hair follicles and sebaceous glands of various mammals. In some (cat, sheep, horse, deer) the consequences of attack are seldom serious, but in others (man, dog, goat, pig, ox) follicular mange is set up, causing loss of hair and the formation of pustules. Only a single species, *D. folliculorum*, is generally recognized, but there are numerous varieties, each affecting a special animal. The cause of the trouble can only be ascertained by microscopical examination, as the mites are very small, not much exceeding $\frac{1}{100}$ of an inch in length. They are wormlike creatures, with eight short three-jointed legs and a short sucking rostrum or beak. Their deep-seated situation in the hair follicles renders them difficult to destroy, but the disease spreads very slowly. In simple cases benzine ointment (1 part benzine to 4 parts lard) is usually efficacious. Creolin has been tried with good results, and the disease has been cured by rubbing the affected parts daily with balsam of Peru dissolved in 4 parts of alcohol. The internal administration of sulphur is also advisable. [C. W.]

Dendrometer, literally meaning 'tree measurer', is the name applied to instruments used to measure the height of trees, as is more clearly expressed by the term Hypsometer. There are many such instruments, differing in special details, and known by the names of their inventors; but they are all necessarily based on the equal proportions of similar triangles. The simplest forms are those in which one side of a right-angled triangle forms the basis of reckoning. In this case (allowing for the height to eye of observer), on level ground and with a view obtained to the tree top at an angle of 45°, the height of the tree equals the distance of the stem from the observer. In other cases the distance from the tree to the observer has first to be measured and the instrument set accordingly, and then the observer moves forwards or backwards till the tree top becomes visible, when the height of the tree must equal the reading shown on the instrument by the corresponding side in the reduced similar tri-



Dendrometer.

angle (due allowance being made for the observer's eye being above or below the tree base). For other instruments, any length of base-line is measured and the angle is taken from the base of the tree to its top, and from these data the corresponding height is ascertained from printed tables prepared trigonometrically. [J. N.]

Denitrification in Soils.—The word 'denitrification' was introduced in 1882 by Gayon and Dupetit (Comptes Rendus, 1882, vol. xcv, p. 644) to denote the decomposition of nitrates with evolution of free nitrogen. Of late years it has come to stand for all losses of nitrogen brought about by bacterial agency. The question whether these losses go on in the soil has been much discussed; they certainly occur when large amounts of nitrogenous manure are added, but it is difficult to settle whether they go on when small dressings are used. Two distinct lines of evidence bear on the question: (1) When an account is kept of the nitrogen

supplied to the soil and the amount recovered in the crop, there is always a deficit. The difficulty of finding how much of this is due to loss by drainage prevents the experiment from being made quantitative, but in the case of heavily manured land the deficit is far in excess of any possible drainage. (2) Certain bacterial and other processes are known which increase the amount of nitrogen in the soil; the increase, however, will not go on indefinitely, but stops after a while. A state of equilibrium sets in, and the gains are counterbalanced by losses.

The best instance of a nitrogen balance sheet is that of the Rothamsted wheat plots. Some of these were started in 1843, and the others in 1852. The manuring has continued without change to the present time. In 1865 the percentage of nitrogen in the soil was determined, and the number of pounds in the top 9 in. and the top 27 in. calculated. The amount added every year by rain and seed was also ascertained. To get the other side of the balance sheet and discover how much was removed, the crops were analysed and an attempt was made to find out how much was lost by drainage. The account was checked in 1893, when the soil was again analysed. The results obtained are given below.

1. The Unmanured Plot, 1865 to 1893 (Plot 3).

	lb per acre.
Nitrogen originally present in 1865 (·1050 per cent) (top 9″)	2722
Nitrogen supplied in manure, 1865–1893 .	0
Nitrogen supplied in rain, 1865-1893 ..	140
Nitrogen supplied in seed, 1865–1893 ..	56
Total expected in 1893	2918
Nitrogen removed in crops, 1865–1893 ...	476
Nitrogen found in soil, 1893 (·0940 per cent)	2437
Total accounted for in 1893 ..	2913

2. Plot receiving Ammonium Salts (containing 86 lb. Nitrogen) and Minerals (Plot 7).

	lb per acre.
Nitrogen originally present in 1865 (·1170 per cent) .. .	3034
Nitrogen supplied in manure, 1865–1893 .	2408
Nitrogen supplied in rain, 1865–1893	140
Nitrogen supplied in seed, 1865–1893	56
Total expected in 1893	5638
Nitrogen removed in crops, 1865–1893	1932
Nitrogen found in soil, 1893 (·1146 per cent)	2971
Total accounted for in 1893 .	4903

Leaving 735 lb. not accounted for.

3. Plot receiving Dung (14 Tons, containing 200 lb. Nitrogen a Year) (Plot 2*b*)

	lb per acre.
Nitrogen present in 1865 (·1752 per cent) .	4,343
Nitrogen supplied in manure, 1865–1893 ..	5,600
Nitrogen supplied in rain, 1865–1893 ..	140
Nitrogen supplied in seed, 1865–1893 .	56
Total expected in 1893	10,139
Nitrogen removed in crops, 1865–1893 ..	1,484
Nitrogen found in soil, 1893 (·2132 per cent)	4,976
Total accounted for in 1893 ..	6,460

Leaving 3,679 lb. not accounted for.

The account for the unmanured plot agrees well; the close agreement is accidental, because some nitrogen is known to be lost in the drainage water and in the weeds removed from the plot (see also art. Nitrogen Fixation in Soils). Plot 7 shows a deficit of 735 lb. in the twenty-eight years, or 26 lb. a year. Some at any rate of this is certainly lost by drainage and weeds; but Plot 2*b* shows the enormous deficit of 3679 lb., or over 130 lb. a year, an amount too great to be put down to drainage. Very similar results are obtained if the calculation is made to 27 in. instead of 9 in. We conclude that denitrification causes no serious loss on unmanured land, or on land receiving moderate dressings of artificials, but it may become serious when heavy dressings of dung are given. This conclusion is confirmed by some of the mangold experiments. One plot receives annually 14 tons of dung containing about 200 lb. of nitrogen; only 31·6 per cent of this is recovered in the crop; some remains in the soil, but much is lost.

In 1895 Wagner and Maercker surprised the agricultural world by announcing that unrotted dung destroys the nitrates in the soil and reduces the crop yield. Their experiments are described in the Journal of the Royal Agricultural Society for 1897 (vol. viii, p. 477), and criticized by Warington (*ibid.*, p. 577), who pointed out that their dressings were enormous, and their results would not apply to ordinary farm practice. By way of illustration he calculated the percentage of nitrogen recovered from the plots receiving various nitrogenous manures in addition to dung. As the later figures cover a longer period they are necessarily more accurate, and will be used here instead of Warington's.[1] The amounts of nitrogen in lb. per acre per annum contained in the roots are:—

	Without Dung.	With 14 tons Dung.
Nitrate of soda, containing 86 lb. nitrogen .	67 2	115·8
Ammonium salts, containing 86 lb. nitrogen	49·3	105·6
Rape cake, containing 98 lb. nitrogen	69·4	111·1
Rape cake, containing 98 lb. nitrogen + ammonium salts, containing 86 lb. nitrogen .	103·0	129.8

When dung alone was applied, 63·3 lb. of nitrogen were contained in the roots.

From these figures we can calculate the percentage of nitrogen recovered in the crops in the two sets of cases.

[1] Hall (Journal of the Royal Agricultural Society, 1902, vol. 63, p 81).

	Nitrate of Soda.	Sulphate of Ammonia.	Rape Cake.	Rape Cake and Sulphate of Ammonia.
Percentage of nitrogen recovered when no dung is used	78·1	57·3	70·9	56·0
Percentage of nitrogen recovered when 14 tons dung are used in addition	61	49·4	48·8	36·2

The amount of nitrogen recovered is less than it should be, and there has clearly been some loss of nitrogen compounds where dung is applied in addition to other nitrogenous manures. But the loss is not serious, and, in fact, the heavier dressings are often found the more profitable. Wagner and Maercker were strictly correct in saying that dung causes a loss of nitrate, but they erred in overestimating its amount and importance.

The other line of evidence showing that loss of nitrogen may occur from soil is the fact that bacterial and other agencies cannot indefinitely increase the amount of nitrogen in the soil. This is clearly shown by the analyses of the Rothamsted grass plots. When they were laid down they probably contained about as much nitrogen as the ordinary arable land on the farm, *i.e.* about ·1 per cent. They now contain much more, but the quantity no longer increases. In 1870 the unmanured plot contained in the top 9 in. ·2517 per cent of nitrogen; in 1886 the amount was ·2532. Clovers and other leguminous plants grow on the plot, and the conditions are favourable to nitrogen fixation; there can be little doubt that this is still going on; but the opposite process, denitrification, has also set in, and the net result is that there is now neither gain nor loss of nitrogen.

We can now explain why the soils of heavily manured gardens, market gardens, and hop gardens rarely, if ever, contain more than about ·25 per cent. of nitrogen. As the 'condition' of the land rises, so the losses of nitrogen rise, and any not taken by the crop is lost; accumulation no longer goes on. Heavy manuring, in fact, can only be economical when every care is taken in other directions to secure a maximum crop

A vast amount of work has been done by bacteriologists on denitrification. It appears that three distinct causes may operate: (1) Nitrates may be decomposed with liberation of nitrogen. (2) Nitrogen may be set free during the decomposition of organic matter. (3) Nitrates and ammonia may be taken up by lower organisms and so, for a time at least, rendered 'unavailable' for the plant. This is discussed under Soil.

1. Decomposition of Nitrates.—Three kinds of decomposition are known: (*a*) Nitrates may be reduced to nitrites and ammonia; (*b*) nitrates and nitrites may be reduced to nitrous and nitric oxides; (*c*) nitrates and nitrites may be reduced to nitrogen. The first of these, (*a*), is not so serious as the others, for the nitrite and ammonia may always be reconverted to nitrate; (*b*) and (*c*), however, represent absolute losses, since the products are gaseous and escape. The reader who desires a full account of the various researches on the subject can find it in Lafar's Technical Mycology; a good account of the earlier work is also given by Warington in the Journal of the Chemical Society, 1888, vol. liii, p. 742. While much remains to be done from the purely scientific side, two facts are definitely established: (1) this decomposition only goes on in presence of organic matter, (2) it is stopped entirely if much air is present. In a well-cultivated soil it is therefore not likely to take place to any great extent, and as a matter of fact the Rothamsted mangold results quoted above show that loss of nitrate from this source is not serious. But in a water-logged soil the case is different; losses may and probably do take place, and they can only be avoided by drainage and aeration. These conditions are found in the swampy soils known as 'paddy soils' on which rice, *Sagittaria sagittæfolia* (used for food), and *Juncus effusus* (for mat making) are cultivated in the Far East. Nagaoka (Bul. College of Agric, Tokyo, vol. vi, No 3) has shown that nitrate of soda frequently depresses the yield on these soils, doubtless because of the formation of poisonous nitrites (cf. also Bul. Imperial Agric Expt. Station, Japan, 1907, vol. i, p 7). Organic nitrogenous manures are therefore always used.

2. Liberation of Nitrogen during the Decomposition of Organic Matter.—This is perhaps the most serious loss caused by bacteria to the agriculturist. Whenever organic matter decays in absence of air, some nitrogen is lost as gas; this is equally true of a dungheap and of soil. It is in this way that the losses of nitrogen from heavily manured soils and from pasture soils are to be explained. The question was investigated at several of the German experiment stations, *e.g* at Augsburg, Darmstadt, Jena, Rostock, Bonn, and Göttingen, as the result of a request from the German Agricultural Association in 1896. Their reports are published in the Landwirtschaftliche Versuchs-stationem for 1897 and succeeding years. It was shown that: (1) If air is excluded, no loss of nitrogen takes place, (2) if air is present, there is considerable loss; (3) no practicable means, except exclusion of air, could be devised for checking the loss. Loss of nitrogen from a dungheap can be reduced by compacting so as to keep out air, but no way has yet been discovered for reducing the losses from a well-manured soil. Indeed in this matter the agriculturist is on the horns of a dilemma: if he admits air to the soil, nitrogen is set free from some of the organic matter; and if he attempts to exclude air, nitrogen is set free from the nitrates.

Summary.—(1) No great loss of nitrogen by denitrification seems to take place from land receiving only the small manurial dressings of ordinary practice. If there is any loss it is fully counterbalanced, or more than counter-

balanced, by gains of nitrogen from the atmosphere.

(2) Where large dressings of dung or other organic matter are applied, the loss becomes great, and seems to increase as the dressing becomes heavier.

(3) For this reason the amount of nitrogen in heavily manured garden soils or in old pastures rarely exceeds about ·25 per cent. Equilibrium is now set up, and the losses equal the gains.

(4) The loss is mainly due to organisms decomposing organic matter in presence of air and liberating nitrogen. In special cases, as in water-logged or badly aerated soils, reduction of nitrate to free nitrogen, *i e* true denitrification, may take place, but there is no evidence to show that it goes on in ordinary soils

(5) No way is yet known of reducing the loss. [E J R.]

Denmark, Agriculture of.—Denmark has a superficial area of 14,800 sq miles, or about half that of Scotland. There are no rivers of any importance, and no mountains. The highest hill is only 550 ft. above sea level. There are no great forests. There is neither coal nor metal. The country does not therefore lend itself to the development of many industries, and the enterprise and the energy of the people are confined for the most part to the development of agriculture. The cultivated land extends to 7,062,000 ac. On the whole it is poor land, with the exception of the island of Fyen, or Funen, which is called the garden of Denmark. It is bare, wind-swept land The winters are long, and the summers are short and dry. It is not an ideal farming country, but possibly it is better adapted for agricultural pursuits than for anything else.

Danish agriculture has had to fight, not only against the forces of nature — unsuitable soil and an indifferent climate,—it has had to fight against a very bad system of land tenure. Up to the latter half of the 18th century the farmers of Denmark held their land either from the parish or from the large landed proprietor. When the parish council let land it included in the lease part of the good and part of the bad land of the parish, with the result that the farms were disconnected and disjointed, which made the economic working of them an impossibility. When the large landed proprietor let land, the farmer practically became his slave. If the farm was a bad farm, he had to work it whether it paid or not. If it was an improved farm, he might be turned out without compensation, and he had always to work for the landlord before he worked for himself, reaping the landlord's crop while his own was spoiling on the fields. By numerous Acts of Parliament, extending from 1769 to the present day, the land of Denmark has been gradually passing from the large landed proprietor to the small farmer, and peasant proprietorship, with all that it means as an inspiration to the right sort of man, has become predominant in Denmark. These figures show how the land of Denmark is now held:—

Estates.	Number.	Total Acreage.	Average Size
¾ to 6 ac	92,656	155,766	1·6
6 to 24½ ac.	66,491	836,658	12·6
Over 24½ ac.	73,889	5,514,978	74·7
	233,036	6,507,402	

While the land system was being reformed, the schoolmaster was abroad. Bishop Grundtvig, who has been called the Carlyle of Denmark, founded the first Popular High School in 1845. These schools, however, did not take root until after the Prussian war of 1864. Then they sprang up everywhere, and there are now over seventy of them in the country, attended by 6000 pupils. The pupils, who are all boarders, are young men and young women, whose ages range from eighteen to thirty. They are drawn from all classes of the community, but mainly from the peasant class. The men attend in winter, when work is slack on the farm, and the women attend in summer. Gymnastics are taught to make the pupils physically fit; reading, writing, and arithmetic to develop the mind; the folklore and the history of Denmark to intensify love of home and fatherland; and the whole system is suffused with a religious spirit. The result is to be seen in the character of the Danish farmers, which accounts to a considerable extent for their pre-eminent position among the agricultural communities of the world.

The Danish system of land tenure and the Popular High Schools do not, however, account for all the success of Danish farming The co-operative movement, which did not take root till the 'eighties, accounts for a good deal. It has eliminated the middleman and brought the producer in direct touch with the consumer. It has enabled the farmer in very full measure to reap where he has sown. Nor must we forget the good part played by the State. It spends with much wisdom and discretion something like £108,000 on agriculture. Besides, it subsidizes ships, and it owns in large part the railways, which, as indicated by the paid-up capital, cost less than £9000 per mile to build, while in Scotland they cost over £47,000 per mile, which will for long, if not for ever, make transit in this country more expensive than in Denmark. Both steamships and railways are run almost entirely with the view of benefiting agriculture, because agriculture is Denmark's one important industry.

Danish agriculture is thus broad-based. It rests securely on the Danish system of land tenure, on the character of the Danish people, on the co-operative movement, and on a well-directed system of State aid. These are the four great foundation stones, but the greatest of them, the chief foundation stone, is *the character of the Danish people.* But for that, the Danish system of land tenure would not have availed. Similar systems in other countries have failed. But for that, co-operation could not have been, and without co-operation, State aid on the Danish principle—self-help first, State aid afterwards—had been impossible. It was mainly on

the character of her people that Denmark depended when in the 'seventies she had to face a world-wide competition, resulting in an agricultural depression which in many a country has not yet passed away. The story of Denmark's agriculture is the story of how her farmers met and overcame that world-wide competition, and how to-day, while other farmers suffer from agricultural depression, they stand in the very forefront of those who make their living by agriculture.

In the 'seventies, Denmark's chief product was grain. Grain growing, which had ceased to be remunerative on good farms, was out of the question on the poor soil and the small farms of Denmark. Some of the wisest men in Denmark saw, before the agricultural depression set in, the wisdom of turning the Danish farmer from the production of corn to the production of butter. Small progress, however, had been made when the full force of the depression was felt. Stern necessity then made a change imperative. We in this country met the same competition by turning arable land into grass, by producing beef instead of corn. It was less expensive to run a ranch than to work an arable farm, and the reduction in the labour bill was a matter of no small importance. Besides, there was at least a prospect for some time at any rate of beef paying better than corn. Denmark met the competition in a totally different way. She ploughed up every available acre; she became more intensive in her cultivation; she materially increased her labour bill. Strange that two nations should meet the same difficulty in so diverse ways. Yet Denmark did nothing strange. Her land was not suited for permanent pasture. Our broad and more fertile acres might compete for a time with the beef producer of the prairie lands. Denmark could not enter such a competition. On the other hand, the size of her farms was an argument in favour of turning them into dairy farms, where the personal attention of the farmer and his family could be given to the stock. Moreover, the market for butter was at Denmark's own doors. It was Britain. It was a rapidly growing market, and a market which a system of intensive cultivation might hold against all the farmers of all the prairies of the western world, until the day when human labour does not count in the production of butter. And so Denmark, with some confidence, set herself to develop the dairy trade.

Cattle.—One of the first things the Danish farmer had to tackle was the breed of his cattle. There were two native breeds. There was the red Danish breed, similar in size to light Ayrshire cattle. They belonged to Zeeland. There was the black-and-white cattle of Jutland. They were bigger than the red cattle of Zeeland. Neither breed was of much use as milk producers. They were, however, the only raw material at the disposal of the Danish farmer. He crossed the red cattle with selected bulls of a similar if not the same breed from Schleswig, and by subsequent careful selection improved the breed. The red Danish cattle have become in the hands of the Danes unrivalled as milk producers. The black-and-white cattle of Jutland, originally kept for beef production, were crossed with Dutch bulls, and have gradually developed into a milking breed, not inferior to the red Danish cattle. Systematic attempts at improvement have been carried out ever since. The Danish farmer has reared for stock purposes bulls whose ancestors have been good milkers, with a high percentage of butter fat. Inferior bull calves have been fattened when young and sold to the butcher. Heifer calves have been reared and served, and the best types ultimately selected for breeding purposes. Judges at the agricultural shows have backed up the farmers. Two methods of judging are adopted. Bulls under three years of age are judged according to appearance. Bulls three years of age and older are also judged by appearance, but not by that alone or mainly. For example, bulls of five years of age must have three years' stock. The stock is judged before the show, and the prizes or premiums are awarded to the bulls according to the merit of their progeny as milk producers. Cows are judged on the same utilitarian basis. The milk yield and the butter fat are the determining factors; not, however, the milk yield and the butter fat on the show day, but the milk yield plus the percentage of butter fat, as shown by the milk records for a certain definite period of time.

The development of a herd of cattle on the above lines necessitates good breeding stock. But how was it possible for the small farmers of Denmark to get good breeding stock? It was made possible by co-operation, supplemented by State aid. When, for example, the farmers of a district need a first-class bull, they apply to the Government stock expert, who selects a bull for them. It is stationed at a central farm. The farmer is paid for its keep, and the farmers of the district pay for the bull by paying so much per cow for the use of the bull. Thus, the best animal is available for the improvement of the stock of the poorest farmer. The development of a herd of cattle on the above lines also necessitates the keeping of accurate milk records. The Danish farmer has learned to do this well. In the most up-to-date byres in Denmark there is a blackboard at the head of each cow, with a few numbers indicating the sire of the cow, her age, her number in the Kontrol Society's books, the quantity of milk given by the sire's dam and by the cow herself, the percentage of butter fat it contains, and the quantity of the butter, the date when the cow calved and when she is expected to calve again, the highest yield of milk the cow has given since she calved last, the present yield, the date when the maximum yield was obtained, and the class into which the cow's yield of milk entitles her to be placed.

The housing and the feeding of the cattle thus bred receive much attention. The byres are well worthy of note. They are the home, in a very real sense, of the cattle, which live, move, and have their being in them, from one end of the year to the other, save for fourteen weeks or so in summer. Many of the byres would not pass muster with the sanitary authorities of Scotland. But it is more than questionable if the sanitary authorities of Scotland have not

gone too far. The best of the Danish byres are in every way admirable. They are 32 ft. wide. There is a central passage 4 ft. wide. The feeding troughs are along both sides of this passage, which is raised to the height of the troughs. From the central passage the cows are fed. The stalls, which are 6 ft. long, have a slope to a gutter at the back, from which the liquid manure is taken to a manure tank. Between the gutter, which is 1½ ft. wide, and the wall, there is a passage, also sloping towards the gutter, 5 ft. broad, to enable the cattleman to remove the manure. Special attention is also paid to the feeding of the cattle. All farming in Denmark is directed towards this end. The land is tilled with this object in view. Something like 70 per cent of every farm is under the plough. The rotation is usually as follows: First year, rye; second, roots; third, barley sown with clover and grass; fourth, clover and grass; fifth, clover and grass; sixth, oats; seventh, fallow. The farmers of Denmark, who keep on an average one cow and some calves to every 2½ ac. of land, import, free of duty, large quantities of feeding-stuffs to augment the produce of their own farms. The farmer aims at two things. He aims at the production of good milk, because he sends the milk to the co-operative creamery and he is paid according to quality. If it is tainted or contaminated, the culprit is warned, and if he commit a second offence he may be expelled from the creamery. He is thus forced to pay particular attention to the feeding of his cattle He also aims at the production of as much milk as possible at a minimum of cost. He therefore not only dispenses with all kinds of food which might taint the milk, but he selects the foods which give the best results, and he feeds according to the milk production. Four standards of food, for example, and some straw are allowed to keep a cow in good condition, and one standard, which may consist of 1$\frac{1}{10}$ lb. of cake, bran, and oats, or 2¾ lb. hay, or 11 lb. roots, is allowed for each 3·3 lb. of milk produced. In arriving at the best and most profitable feeding, he is greatly helped by the Kontrol Societies. These societies are formed by the farmers themselves. A number of farmers, having say 1000 cows, may form a society. On the formation, the Royal Danish Agricultural Society will appoint an inspector, a practical man, probably with a university training, who goes from farm to farm, visiting each farm every two or three weeks. He keeps a double set of books relating to each farm, one for himself and one for the farmer. He takes note of the breed and the feeding of the cattle, of the milk production and the butter fat, and comparing his statistics thus obtained, he is able to give material help to the Danish farmer.

The result of all this care in the selection of breeds and in the feeding of cattle is observable in the increased milk supply. Let me give one example, which is typical. At Kolle-Kolle. a farm visited by a company of Essex farmers in 1900, the average milk yield was about 700 gal. per cow. The Scottish Agricultural Commission visited the same farm in 1904, and the average milk yield had risen to 824 gal. It is more observable in the development of the dairy trade of Denmark. In 1860 the British Consul at Copenhagen wrote: 'The butter, or the article sold in the market by the yeoman farmers under that name, is execrably bad'. The export trade at that time was insignificant. The average of the years 1865 to 1869 was only 87,907 cwt. In the year 1882 it had increased to 222,233 cwt. Just then the co-operative movement in Denmark began. The first co-operative creamery was started in Jutland in 1882. It was started by the farmers. Its origin and constitution is similar to the origin and constitution of all the other 1100 co-operative creameries. No money was subscribed; each farmer bound himself to send the milk of a specified number of cows, and a Loan Company, on the personal undertaking of the farmers, each farmer becoming liable for all the farmers, advanced the money. A most marked development followed the introduction of co-operation. These figures, which show the export of Danish butter, speak for themselves:—

Year	Exports
1882	222,233 cwt.
1896	887,076 ,,
1903	1,533,000 ,,
1907	1,679,464 ,,

The money value of the exports for 1907 amounted to £9,388,888.

Pig-rearing and Bacon-curing. — Pig-rearing, as we know it in Denmark to-day, is the result of the development of dairy farming. Pigs were reared to get rid of the refuse of the dairy, and they are fed, in part at least, on separated milk, which the farmers of Denmark have found exceedingly suitable for this purpose. Before the days of dairying, Denmark bred pigs, though not as she breeds them now. They were then sent to Germany. By and by, proprietary bacon-curing establishments were started in different parts of Denmark, and these competed with Germany for the home-reared pig. The Danish farmer, it must be admitted, favoured the foreigner, not because he had any liking for him, but solely on account of the fact that the Germans took fat pigs, and the bacon-curers of Denmark, finding that the taste for these was diminishing, catered for the younger and leaner animal. The Dane was of opinion that the profit to him was made between the age of the pig when the Danish bacon-curer wanted it, and the age when the less fastidious German took it, and so he had a very natural preference for the German. This continued till 1887, and in that year there were 232,000 pigs exported, of the value of £833,300, and bacon and ham were exported of the value of £666,700. One million and a half yearly was a good return from pig-rearing. 1887, however, saw the end meantime of the keen competition, for swine fever broke out in Denmark, and the German ports were closed in the face of the Danish exporter. The export of swine fell at once from 232,000 to 16,000 per annum. This misfortune to the farmers of Denmark put them in the way of making, if not a fortune, at least a considerable sum of money. They went on rearing pigs as before, only more of them. Between 1891 and 1895 the export

trade in pork had reached the considerable sum of £1,722,209, and Germany, which had again opened her gates, was receiving pigs to the tune of £566,600 per year. In 1896 Germany again prohibited the importation of swine. Denmark, however, had made provision for this. When it occurred in 1887 the farmers had started bacon-curing factories. The factories were floated in the same way as the creameries had been floated. The members agreed to send their pigs to the factory and to become responsible, jointly and severally, for the liabilities. The essence of this is that every member is known to every other member, and this was possible in the case of a creamery catering for the milk of a limited district. In the case of a bacon-curing factory, however, which had to draw from a much wider area, it was impossible that there could be that personal knowledge which was so essential. To get over the difficulty the members in a parish agreed to supply a certain number of pigs and become jointly and severally liable for the sums which the bank was ready to lend to the parish. Slaughter-houses soon sprang up in different parts of the country It was no longer possible for the Dane to go on producing the old porker. The taste of the public, particularly the British public, which he had to feed, was changed. The animal now wanted was an animal small in the head, narrow in the shoulders, long and deep in the sides, with thick flank and square hind-quarters, weighing from 140 to 160 lb. at seven months. The bacon-curers of Denmark and the Government took the matter in hand. They sent experts to England to procure good boars of the Yorkshire type, and crossed them with the native sows to get the desired animal. They are reaching the same results by the improvement of their own breeds. Meanwhile, bacon-curing has become one of the great industries of Denmark, and to-day most of the trade is in the hands of the co-operative societies. There are 60 slaughter-houses in the country; 36 are worked on co-operative lines. The total export from Danish factories in 1907 amounted to 1,885,714 cwt., for which the Dane received £5,333,333.

Poultry. — The poultry trade of Denmark ranks next in importance to the pig trade. Poultry-keeping is not a trade by itself in Denmark. There are few poultry farms, pure and simple. The poultry form part of every farm. There may be ten head of poultry or there may be three hundred head of poultry on a farm. That depends upon the size of the farm. It is the universal practice of keeping poultry on all farms which accounts for the enormous production of eggs in Denmark. The Danes have with their characteristic utilitarianism discarded fancy show breeds. They breed for the production of eggs. The varieties kept are: Brown Leghorns, Plymouth Rocks, Wyandottes, Minorcas, and Orpingtons. The profit made runs from 2*s.* 6*d.* to 3*s.* per hen per year, but, the middleman being removed, the Dane gets all the profit. Co-operation has done as much for the egg trade of Denmark as for any other branch of Danish farming. There are over 500 poultry societies. Each society employs a collector to collect the eggs from its members once a week. The eggs are weighed, and paid for according to weight. They are stamped with the farmer's stamp and with the society's stamp, and forwarded in wooden boxes with cardboard divisions to one of the central shipping stations, where they are graded, tested, and packed for export. The trade has developed with the passing of the years. Last year Denmark exported eggs worth in round figures £1,500,000.

The total export of Danish goods in 1907 amounted to £23,111,111. The total export of Danish agricultural produce in 1907 amounted to £20,777,777. It is evident that, apart from agricultural produce, Denmark's exports are insignificant. But what did her agricultural exports in 1907 consist of? They consisted mainly of three items, viz. —

Butter	£9,388,888
Bacon .	5,333,333
Eggs .	1,500,000
Together	£16,222,221

It is noteworthy that Denmark, depending almost entirely on agriculture, and almost entirely on that part of agriculture concerned with the production of butter, bacon, and eggs, has infused new life into her farming, and has actually grown rich during the years of agricultural depression. After Great Britain, she is now the wealthiest country per head of population in Europe, and her wealth is generally diffused among her people. [J. M. H.]

Dentition. See Age of Animals.

Depopulation, Rural.—The facts on this subject, which excites attention in almost every European country and in the United States of America as well, are set forth most authoritatively, as far as the United Kingdom is concerned, in the Report on the Decline in the Agricultural Population of Great Britain, 1881–1906, published by the Board of Agriculture in 1906. It was written by Mr. R. H. Rew, now chief of the Statistical Department. The principal object was to discover whether the decreases in the rural population, exhibited up to 1901, had continued in the same direction since that date. It may be convenient first to set out these figures:—

Class.	1881.	1891.	1901.	Increase (+) or Decrease (–).	
				1881-91	1891-1901.
Farmers and graziers	**279,126**	**277,943**	**277,694**	**–1,183**	**–249**
Farm bailiffs—foremen	**22,895**	**21,543**	**27,317**	**–1,442**	**+5,864**
Shepherds	**33,125**	**31,686**	**35,022**	**–1,439**	**+3,336**
Agricultural labourers—farm servants ...	**983,919**	**866,543**	**689,292**	**–117,376**	**–177,251**

The information obtained by Mr. Rew was gained from 248 replies received from the official correspondents of the Board in different parts of England, Scotland, and Wales.

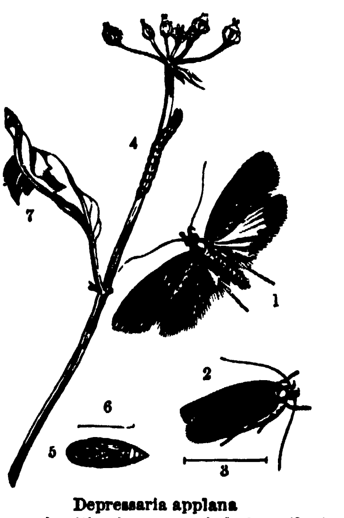
Mr. Rew's first point is that the number of farmers and graziers returned in the census does not bear an accurate relation to the number of occupiers of agricultural land. In other words, many of the men enumerated gained only a part of their livelihood from farming or grazing. Again, the class termed 'farm bailiffs—foremen' in 1901, was described as 'farm bailiffs' simply in the 1881 and 1891 censuses. On looking closely into the figures it appears that during the twenty years 1881–1901 farmers and graziers had decreased in 40 counties and increased in 48; farm bailiffs and foremen had decreased in 31 and increased in 36; and agricultural labourers had decreased in every county except Anglesea and Flint. Some increase of the farmer class had taken place in five English counties and in Inverness, in consequence of the splitting up of large holdings into smaller. On the question of the rate of decline in the labouring population since 1901, Mr. Rew found that the belief was entertained in one or two counties that the rate of decline had been accelerated, while in others, such as Middlesex and Ayrshire, labourers were said to be more numerous than in 1901. On the whole, the Assistant Secretary's impression is that since 1901 there had been 'some further reduction in the number of men employed on farms, but that the diminution is proceeding at a slower rate than during the ten or twenty years preceding that date'. It should be borne in mind that the figures in the censuses are based on the description which men have themselves given in their census papers. There were possibly, therefore, more persons engaged in the work of the land at busy times than the returns indicate. The replies of the Board's correspondents pointed to the fact, however, that there was a greater reduction in casual labour than in permanent labour. The extension of fruit growing and vegetable production had nevertheless increased in some districts the amount of casual labour.

As to the general question, if the decline in agricultural labour were only 15 per cent per decennium it would be none the less a grave matter. As Mr. Rew points out, the reductions of the past twenty or thirty years had an importance greater than those recorded previously. Before 1870 there was in many districts a superfluity of labour, and many of the labourers returned in the censuses were only in partial employment. 'The elimination of these represented, therefore, a less serious withdrawal of labour from the land than the loss of an equal number at the present time, when employment is more general.' (In the seventies, it must be remembered, farming was prosperous; 'lands' valued in 1906 at £42,000,000 were then valued at £60,000,000, and wheat was never below 45*s*. per qr.). Bearing upon Mr. Rew's belief that 'the demand for farm labour has been restricted as the supply has declined, and that something like an equilibrium has been so far maintained', there is the fact brought out in Mr. Wilson Fox's investigations, that whereas in 1871–81 the increase in earnings per week per man was 11·8 per cent, and in 1881–91 1·3 per cent, it was in the decade preceding 1901 some 5 per cent. Mr. Rew holds it proved that the withdrawal of 2,000,000 ac. of land (the area of Hants and Somerset) from the plough during 1881–1901 threw out of work from 60,000 to 80,000 labourers; but the putting down of land to grass did not entirely account for the reduction in labour. Detailed figures show that the saving of labour on the land which had remained under plough in 1901 was greater during the twenty years than on the 2,000,000 ac. which had been laid down to grass. The effect of labour-saving machinery has to be taken account of. To the greatly extended use of drills, horse hoes, mowers, binders, &c., Mr. Rew thinks, 'more than any other single cause, the reduced demand for farm labourers may be attributed'. Mr. Rew does not mention the point, but it must not be forgotten that the rapid extension of towns must be considered to have diminished the area available for agriculture. Mr. Rew's third cause of rural depopulation is the increasing desire of young labourers to leave the land for the towns. Again, from more than thirty counties a deficiency of adequate or satisfactory cottages was officially reported as a cause of discontent. The standard of living of the labourer, as of other classes, has been raised, and better housing is looked for. Another reason for the decline in the rural population was stated by a number of correspondents to be the lack of financial encouragement to remain on the land; men left in order to better themselves. Finally, in the list of causes to which Mr. Rew's correspondents attribute the exodus from the land, is an unsatisfied demand for small holdings (varying, of course, greatly in size according to the agricultural usage of the district from which it emanates).

So far Mr. Rew's invaluable report. 'Migration is humorously described', says Mr. Thomas Hardy, 'as the tendency of the rural population towards large towns, being really the tendency of water to flow uphill when forced by machinery'. Rural residents of experience are in no doubt whatever as to the nature of that 'machinery'. With the spread of elementary education, the increase in the number of newspapers, and the enlarged facilities for travelling, the sentiments which lead the town workman to make his sons clerks and his daughters shop girls, were bound to operate among the labouring classes of the country districts. The change in the outlook of the countryman has come at a time when the attractions of the town have increased and emigration to the Colonies has been made easier and more attractive. The countryman is no longer a countryman of necessity but by choice. In these circumstances it is of the utmost importance that nothing should be left undone to keep before the agricultural labouring class the advantages of rural life over urban. In many parts of the kingdom it is plain that the rate of wages will have to be increased. The wages paid in a county like Oxfordshire are such as would hardly be credited by the

farm hands of the north. The conditions of employment in many southern districts are also such as would not be submitted to by north-country labourers. Men are still docked half and quarter days. On the other hand, it is little use raising wages if the wage-earning class does not know how to use a larger income to advantage. The system of education in rural schools still leaves not a little to be desired. There is also needed in many parts of the country what may be called secondary education in the economies and decencies of life. The standard of living needs to be raised. There is an immense amount of work to be done by public-spirited rural residents and the rural clergy and ministers. In some districts it can hardly be said that the Church has had the influence on the social life of the people that it might have had. Increased facilities for obtaining technical instruction in rural industry must prove the source of encouragement to young people which they have proved to be abroad. Albeit the demand for small holdings has been ridiculously exaggerated in some quarters, the provision of reasonable means by which the qualified and deserving are able to get their feet on the ladder leading to the position of small farmer must also have the result of retaining in the country many ardent spirits who would otherwise fail to see there adequate opportunities. Trade unionism among agricultural labourers has failed so far, but farmers have to realize that in the next generation it may conceivably be a force to be reckoned with, and that in any case the labourers of the future will occupy a stronger position in the wages market than their fathers and grandfathers did. [J. W. R. S.]

Depressaria is a genus of Moths, whose caterpillars do great mischief to various umbelli-



Depressaria applana
1, The moth with wings expanded; 2, moth at rest; 3, natural length; 4, caterpillar on carrot; 5, 6, pupa; 7, pupa inside leaf

ferous plants, when left for seed, such as carrots and parsnips, by eating off the flowers and capsules, sometimes even stripping off the leaves. They generally draw the flower-heads together, with a silken web, for a habitation; and when the seed vessels are consumed, they either remove to an unoccupied tuft of flowers, or change to pupæ, sometimes in the web, at others in a leaf rolled up, or within the stem, which they pierce, and there remain secure.

D. applana (the Common Flat-body Moth) is of a pale-yellowish mouse colour, with long horns, and two hooked feelers; the upper wings often have a reddish tinge, with brown spots, and three white dots, in a line, on the centre of each. It rests with the wings lying flat on the back. The caterpillar is green, with three dark lines; a black head and thorax. It feeds on the seeds of the carrot and parsnip, and changes to a brown pupa, in a leaf rolled up.

D. daucella (the Carrot-blossom Moth).—The larva feeds also upon flowers and seeds of carrots and parsnips. The moth is similar to the foregoing; but the upper wings are smoky, with broken blackish lines, and white and ash-coloured dots.

D. depressella (the Purple Carrot and Parsnip Moth) is smaller, but equally mischievous in its economy. The upper wings are of a chestnut colour, often with some whitish patches, forming an irregular oval on each disk; the head and thorax are whitish ochre. [J. C.] [C. W.]

Derbyshire Cheese.—A useful, toothsome, nutritive item of diet has Derbyshire cheese erstwhile been, and nothing more. It has developed no special or distinguishing features, nor has it ever had a repute such as Cheshire, or Leicestershire, or Cheddar cheese have enjoyed throughout long periods of time. But there can be no sounder or wholesomer cheese made from purer milk, none that will ripen slower and keep longer, than the cheese that is made amongst the hills and dales and breezy uplands on the limestone soils of the Peak of Derbyshire.

It is to all intents and purposes a middle-class sort of cheese, of somewhat nebulous origin so far as any approach to uniformity of system in the making of it is to be noticed. With a process so full of variants, each a fancy of the dairymaid who puts it into practice, it is no wonder that a good deal of differentiation is to be found in the character and features of Derbyshire cheese. For all that, however, variable though it be — or rather, variable though it formerly was—it is as a rule a pleasant cheese on the palate, as it is certainly a good digestive.

Until modern times, Derbyshire cheese was made once a day only, as a rule, though in some cases, when the weather was hot, it was made both morning and evening, in order to avoid possible souring of milk in nighttime. The aim always was, in olden days, to make 'sweet-curd' cheese, that, salted only on the outside, and that only after the first day, the curdy mass was given an opportunity of developing some degree of acidity, the which is indispensable for the production of cheese of uniformly high quality and character. Leaving new cheeses unsalted for a day was therefore instinctive, for the why and wherefore—the scientific principles involved —were not understood by the makers.

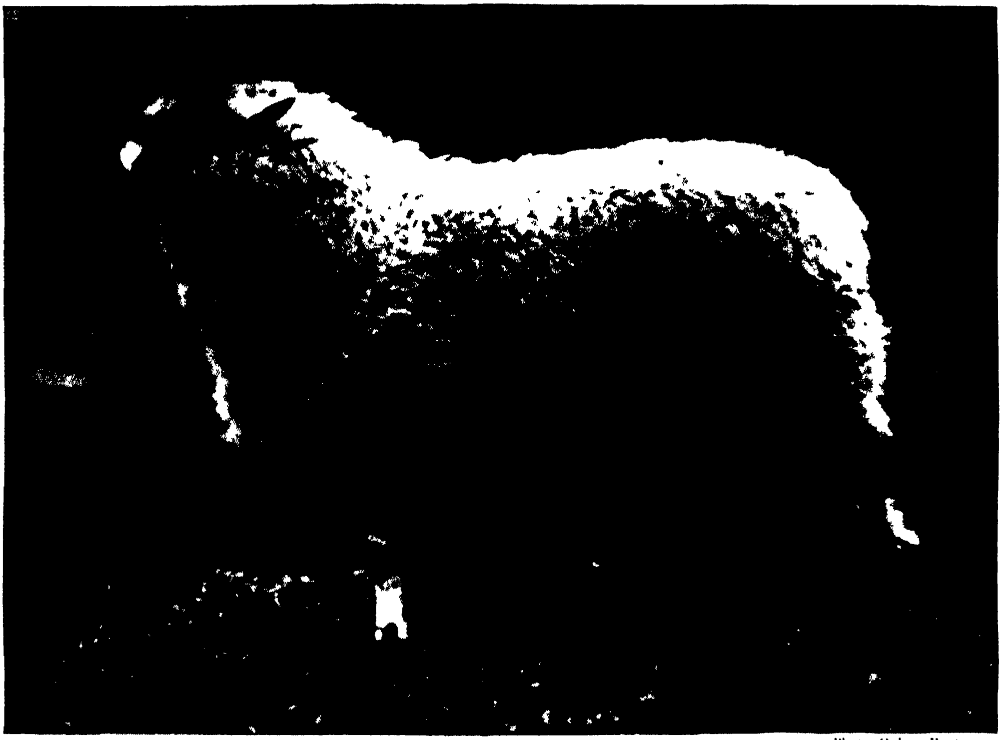


Photo Oakes, Buxton

CHAMPION DERBYSHIRE GRITSTONE RAM—"ERRWOOD CHALLENGER"

Photo. Oakes, Buxton.

GROUP OF DERBYSHIRE GRITSTONE EWES

WINNERS OF FIRST PRIZES AT DERBY COUNTY SHOW, 1908, BAKEWELL FARMERS' CLUB SHOW, 1907 AND 1908

Half a century ago there was a well-known farmer of his day in the Peak of Derbyshire, who occupied a hill-and-dale farm covering over 300 acres on Carboniferous Limestone formation —a farm carrying some 45 to 50 cows in milk, plus young stock, horses, and 150 breeding ewes. One day in early summer a few pounds of curd were accidentally laid aside in a pan and not found until too late to be put into one of the cheeses of the day. On advice of the farmer himself, his wife (parents of writer) kept the truant curd, put it into one of the following day's cheeses, marking it by pressing a penny into one of its flat sides. That particular cheese was superior to all the rest, and the practice of keeping a small quantity of curd from one day to the next, allowing it to become acid, in which condition it was mixed with fresh curd in following day's cheeses, was continued. This was a case of fortunate discovery of the fact that a moderate development of lactic acid in curd is necessary to the production of first-class cheese. This particular dairy of cheese stepped at once into the front rank, and a whole year's make of it—from 6 to 7 tons—realized 87*s.* per cwt.

Made with the natural—and indeed scientific —aid of the lactic ferment (*bacilli acidi lactici*), Derbyshire cheese takes rank with the best of other counties, as a mellow, nutritious, agreeable relish, though the time has slipped by during which a distinctive reputation and a name might have been acquired.

For, alas! as a sequel to the ubiquitous milk trade, the making of cheese as a county industry seems to be approaching a moribund condition. However, the art may haply be kept alive until, when the clouds roll by, there may be incentive of profit sufficient to bring about a restoration of a once extensive, highly important industry in the county of Derby. [J. P. S.]

Derbyshire Gritstone Sheep.—This breed of sheep, indigenous as it is to the hills and dales on the Millstone Grit formation, is probably one of the oldest in the British Islands. Amongst the southern spurs of the Pennine chain which are found in this region of the Peak of Derbyshire—alike in Cheshire, Derbyshire, and Yorkshire—these sheep established, centuries ago, their aboriginal home. To have survived until now, and to be still numerous in the mountainous districts of the three counties named, so far as the Pennine range is concerned, and moreover to possess adequate size and vigorous constitutions, would seem proof sufficient as to the antiquity of the breed. Documentary evidence as to this antiquity of the breed is not as yet forthcoming, but tradition amongst the hills avers that, from time immemorial, these sheep have existed where they flourish to-day. There can be no doubt, indeed, in the mind of him who has become familiar with these sheep on their native heath, amidst ling and furze, rocks and boulders, that they are exceptionally hardy and wiry, possessing a priceless immunity from ills that palefaced sheep are heir to in the lowlands, and endowed with the persistent energy common to denizens of bleak and ruthless mountainous districts. Hence, indeed, their physical prepotency when crossed with other breeds of sheep.

As the writer is informed by the secretary of the Derbyshire Gritstone Sheep-breeders' Society: 'Latterly an uncertain amount of alien blood has been introduced, and still the Gritstone character of such crosses strongly predominates. This fact must prove', as he aptly suggests, 'that the sheep for many generations have been bred pure, or otherwise their characteristics would have almost entirely disappeared in recent times.' The alien blood introduced has been that of the 'Lonk', the Scotch 'Blackface', and the 'Limestone' sheep of Derbyshire. Such crossing, however, has been only sporadic, and not by any means general. 'Limestones' is the generic name of 'Leicesters' that have been bred for many generations—not of sheep only, but of men—on the Carboniferous Limestone uplands of the Peak country, joining up to the habitat of the Gritstone sheep.

It is already borne in upon the intelligence of leading breeders of Gritstone sheep that as no alien blood so far infused has apparently modified the salient characteristics of these sheep, so none of it is likely to effect much improvement amongst them. It is considered discreet, indeed, to beware of meddling with ancient breeds, lest incurable mischief should be the sequel. Apart from such crossing as may have taken place, there are many pure-bred flocks of Gritstone sheep in the district over which the influence of the recently formed Gritstone sheep society extends. It is the object of the society to register and secure the identity of these pure-blooded animals, and to establish pedigrees, as well as to encourage and to systematize a wide-spread recognition and propagation of pure blood throughout the exposed mountainous district to whose rigorous climate, and short commons in winter, these pure-bred sheep have, in the lapse of centuries, perfectly adapted themselves.

The Gritstones are not a whitefaced, or a blackfaced, or even a brownfaced breed, but 'mottle'-faced, with irregular patches of black on white ground, on faces, ears, and legs alike. Their fleeces, however, are 'free from black spots, free also from hair, and from roughness in the skirt'; whilst the wool is of fine texture it is fairly dense and long. The wool is of average, and the mutton of more than average quality. This mutton runs up to 15 lb. a quarter, carcass weight, and in some cases it is said to have turned the scale at 20 lb., or even more, in exceptionally well-developed specimens. Fleeces of wool from ewes run on an average up to about 4 lb., and to 7 lb. and 10 lb. from yearlings and rams respectively.

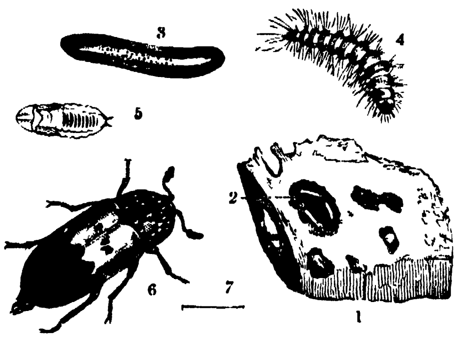
In the Goyt district, where three counties—Cheshire, Derbyshire, and Staffordshire—meet in the midst of the mountains, the breed is declared to be of high antiquity. One well-known breeder there, Mr. W. Truman, traces these sheep back—in possession of his own ancestors—to the middle of the 18th century. During this long interval the breed has been jealously guarded against alien crosses. The ewes are described as excellent dams and nurses, and the lambs are hardy and energetic like their

mothers. Ewes are not housed in the lambing season, and lambs born amidst deep snow take no harm from the severe climatic conditions prevalent at times in the district.

Wiry, active, robust, these sheep are perfectly at home on bleak hillsides, making a good living off the tough grasses native to the soil of the uplands. Such mountain soils in swampy situations are sodden with wet where deep enough to contain it, but for all that, the sheep enjoy immunity from liver rot in the wettest of seasons. Purity of breed and antiquity are virtually guaranteed in the fact that these sheep have lived and thriven unimpaired for centuries where most lowland whitefaced sheep would perish in a year.

The first volume of the Gritstone Flock Book was published in 1907, with entries of 67 rams and 1306 ewes. The familiar features of the late Duke of Devonshire, the first president of the society, are seen in a faithful portrait that will long be treasured by many men. Portraits of some of the leading breeders of Gritstones are also given, along with those of the treasurer and of the secretary. The society was formed on 15th October, 1905, and its headquarters are at Bakewell. [J. P. S.]

Dermestes lardarius (the Bacon Beetle) is a dreadful pest in the kitchen and larder,



Dermestes lardarius (Bacon Beetle)
1, Piece of cheese infested, 2, eggs, 3, egg magnified; 4, larva; 5, pupa; 6, 7, beetle magnified and natural length.

feeding on bacon, cheese, &c., and laying its long whitish eggs in the cavities; these change to little fox-coloured hairy larvæ, which in a month become as large as in fig. 4; having moulted several times, they are transformed to whitish pupæ, with some short reddish bands on the back (fig. 5). In August the beetles hatch; they are dull-black, having a pale buff band across the elytra, on which is a line of black spots; the antennæ are short, with tawny clubs; the thorax is speckled with white; it has two ample wings, and six legs. The female has a hairy ovipositor. A storeroom infested by this insect should be cleared out and sprayed with benzine, or fumigated with carbon bisulphide. Fine wire gauze should be placed over the windows to prevent the beetles from entering. [J. C.] [C. W.]

Deserts.—Regions with small rainfall may prove to be virtually desert regions from an agricultural point of view. Observations must be made in new countries over many consecutive years before exceptionally dry lands are pronounced fit for settlement. Though the soil of desert areas may be naturally fertile, its treatment, when water has been brought into it by stream diversion, or by the tapping of an underground artesian system, is in the first place a struggle against deleterious salts, which the absence of rain has allowed to accumulate in the soil (see art. ALKALI SOILS, and later in the present article). Carbonate of lime may even form a rocky crust some feet thick upon the surface, being deposited where the waters from below, which held it in solution, dry away. The more soluble calcium sulphate and sodium chloride often remain in desert lakes and pools after calcareous tufa has been deposited. In semi-desert regions, like much of the interior of Cape Colony, a heavy seasonal rainfall may wash away the salts, but may also remove the fine earth from what otherwise would have formed a useful soil. Hence the surface is a mere mass of stones, derived from the rock floor, which is often visible over wide areas. The products of disintegration during the long and hot dry season have no moisture to hold them together, and are partly blown away, partly swept out of the country by the flood-like rush of the first rains. The only remedy is to patiently maintain a moistened surface. The Chinaman with his buckets borne by hand across the planks, the settler in Mashonaland seizing on some trickle from the hills to fill an irrigation-cut a few inches wide, and the State-subsidized engineer constructing the huge dams upon the Nile, are all alike engaged in utilizing unexhausted but semi-desert soils.

There are many regions, however, where climatic changes are in progress, and where the desert inevitably encroaches on the habitable land. This is true of the Lob Nor area in Central Asia. The nature of the problems to be faced in another area of desiccation, that of Utah, is well seen from the report by Messrs. Gardner and Stewart on A Soil Survey in Salt Lake Valley, Utah (U. S. Depart. Agric., Report No. 64, 1899, p. 77). [G. A. J. C.]

DESERT SOILS.—The barrenness of deserts is mainly due to the presence of excess of mineral salts, which, in extreme cases, show on the surface of the ground as a white efflorescence. Whenever the annual rainfall is much below 20 in., it is too small in quantity to reach the natural drainage system, and all the salts formed in the process of rock-weathering remain in the soil and subsoil, and are being continually brought to the surface by capillary action. These salts may not be deleterious in themselves, but wherever carbonate of soda, known as 'black alkali', occurs, both seeds and plant roots are directly injured by its corrosive action. The majority of plants are quite unable to absorb any food materials unless they are presented to them in an extremely dilute form; when their roots come into contact with stronger solutions the plants wilt and die as if from want of water. It has been proved by the American experiments

on the alkali soils at Billings that with a concentration of more than 1 per cent of soluble matter in the soil moisture the ordinary agricultural plants will not grow.

In the salt-contents of the soils of arid regions are found included considerable quantities of fertilizing ingredients in an easily available form. Analyses show that these soils possess potash and lime in quantities far above the average of the soils of humid climates, though their soil-content of phosphoric acid does not exhibit a similar surplus. Their supply of nitrates, also, is frequently very large, so that, chemically considered, they possess all the elements of a high fertility. It needs but the removal of the excess of 'alkali' salts to make these deserts bloom as gardens.

Various devices have been adopted for the reclamation or utilization of desert soils. An obvious plan is the growth of a crop that shows a toleration for the 'alkali' salts. This method is largely resorted to in the reclamation of the deserts of Egypt.

Prevention of evaporation by mulching, or by maintaining a loose tilth at the surface, helps materially to prevent the rise of salts to the surface soil. Treatment with gypsum, under certain conditions (see art. ALKALI SOILS), is effective in the case of 'black alkali' lands. Irrigation with under drainage is, however, the supreme remedy; but even this can be overdone, and much fertile land in America has been ruined through the 'rise of alkali' brought about by injudicious irrigation. [T. H.]

Destructive Insects and Pests Acts.—With a view to preventing the introduction to Great Britain of insects destructive to crops, trees, and bushes, and for the purpose of preventing the spreading of any such insect or pest, two Acts have been passed. Of these the first was passed in 1877, and was directed against the prevention of the ravages of the insect commonly called the Colorado Beetle. The Act provided that the Privy Council (now the Board of Agriculture) might from time to time make such Orders as they thought expedient for preventing the introduction of the insect, and for that purpose might prohibit the landing in Great Britain of potatoes or other vegetable substance which might be likely to introduce that insect, and making provision for preventing the spreading of the insect. Compensation is to be paid for the removal or destruction of any crop according to the following provisions:—

1. In the case of a crop on which the said insect, in any stage of existence, is found, the compensation shall not exceed one half of the value of the crop.

2. In every other case the compensation shall not exceed three-fourths of the value of the crop.

3. The value of the crop shall in each case be taken to be the value which, in ordinary circumstances, the crop would have had at the time of its removal or destruction.

4. The Local Authority may, if they think fit, require the value of the crop to be ascertained by their officers or by arbitration.

5. The Local Authority may, if they think fit, withhold compensation if, in relation to the crop, the owner or the person having charge thereof, has, in their judgment, done anything in contravention of, or failed to do anything in compliance with, any Order under this Act.

The second Act was passed in 1907, and extends the 1877 Act to all pests destructive to agricultural or horticultural crops or to trees or bushes. It is, however, provided that the Board of Agriculture shall not make an Order directing the payment of compensation by the Local Authority for the removal or destruction of any crop or any trees or bushes, unless the Local Authority consent to make the payment. The Act applies to Ireland as well as to Great Britain.

Three Orders have been issued by the Board by virtue of the powers conferred by this Act, two of which have special reference to the American Gooseberry Mildew. These Orders are dated respectively 29th November and 10th December, 1907. Their effect is to prohibit the importation of gooseberry and currant bushes from any place out of Great Britain; to impose on the occupier of premises in which disease exists, the duty of notifying the fact to the local authority and of taking certain precautions to prevent the spreading of the disease. Powers are also conferred on local authorities to take measures for the prevention of the spread of the disease.

The precautions to be adopted by the occupier are as follows:—

1. As soon as practicable he shall spray all the diseased bushes and all gooseberry and currant bushes on the ground to which the disease is likely to spread with a fungicide approved of by the Local Authority for that purpose; provided that this provision shall not apply to bushes which have shed their leaves.

2. No bush is to be removed from ground on which there is a bush diseased or suspected of disease, and clippings from such bushes are to be forthwith burned or otherwise destroyed.

The Local Authority may prohibit the picking of a fruit crop when they are satisfied that disease might be spread to other premises by the gathering of the crop.

The local authority is empowered to require the adoption of precautions on premises adjacent to infected premises.

The Third Order is dated 18th June, 1908, and by it the occupier of premises on which any of the insects or pests mentioned in the Schedule are found must at once notify the fact to the Board, sending along with the notice, where practicable, a specimen of the insect or pest. It is not necessary to notify the Board where a similar notification to the local authority has been made in pursuance of another Order of the Board. The officers of the Board have powers of entry to examine for the existence of such insects or pests; and it is declared unlawful, except with the written permission of the Board, to sell or expose for sale or to keep such live insects or pests. Every person is liable on conviction to a penalty not exceeding ten pounds who—

1. Knowingly fails to notify the discovery of such insect or pest;

2. Sells or exposes for sale or keeps an insect or pest; or

3. Wilfully obstructs any officer of the Board when acting under the Order.

The Colorado Beetle Order, 1877, is revoked by this Order. The Schedule referred to is as follows:—

Insects to which this Order applies: The Vine Louse (*Phylloxera vastatrix*, Planchon); the San José Scale (*Aspidiotus perniciosus*, Comstock); the Mediterranean Fruit Fly (*Ceratitis capitata*, Wiedemann); the Colorado Beetle (*Doryphora decemlineata*, Say); the Large Larch Sawfly (*Nematus Erichsonii*, Hartig).

Pests to which this Order applies: Black Knot (*Plowrightia morbosa*, Saccardo); White Root Rot (*Rosellinia necatrix*, Prillieux et Delacroix); Black Scab or Warty Disease of Potatoes (*Chrysophlyctis endobiotica*, Potter(?), of Schilbersky); the American Gooseberry Mildew (*Sphærotheca mors-uvæ*, Berkeley and Curtis). [D. B.]

Deutzia, small ornamental, hardy deciduous shrubs belonging to Saxifrageæ, and natives of the Himalayas, China, and Japan. The flowers are white or purplish, and are produced in May or June. The only objection to these charming plants for outdoor cultivation is that the flowers are liable to injury by late spring frosts. *D. gracilis* is of great value for gently forcing into flower for the conservatory in spring. Deutzias are well suited by a good loam, and are generally increased by cuttings. The best species are *D. crenata*, 8 to 10 ft., white flowers, and its varieties; *D. gracilis*, 3 ft., white flowers, and its varieties; *D. kalmiæflora*, white and purple flowers; and *D. scabra*, 6 to 8 ft., white flowers. There are also some good hybrids, such as *Limoinei* and *Vilmorini*. [W. W.]

Development, the process by which the fertilized egg cell, whether of plant or of animal, gives rise to the fully formed organism. It is impossible to draw a precise line marking the end of development, especially since some organs go on developing longer than others, but there is often a stage at which it can be said that the young creature has now got all its organs and distinctive features established, and henceforth requires only to grow. Development, like growth, has as one of its conditions cell division, but it is marked by change of structure, and in cases like the brain of mammals development goes on after birth though there is no further multiplication of nerve cells. The point is that development is a *progressive* change from one stage to another, meaning by progressive that there is an increase of complexity and of co-ordination. More technically, development implies an increased *differentiation* (the acquisition of new parts) and an increased *integration* (the harmonious correlation of parts). Out of the apparent simplicity of the fertilized egg cell comes the obvious complexity of the young creature.

There are three points of view from which it is particularly useful to think of development, which, it must be remembered, is one of the most difficult problems of biology. (1) Development is for the individual what evolution is for the race, but steps which may have taken the race thousands of years to secure are taken by the individual embryo in a day. In a general way it is true that the development of the individual animal is like a condensed recapitulation of the evolution of the race. This is particularly well seen in the case of particular organs, such as brain, heart, kidneys, the stages in the development of which often correspond to the permanent state of affairs in animals lower in the scale. Thus the frog's heart is in the young tadpole in many ways like that of a young fish, and the kidney of a mammal begins as a double row of kidney tubes, such as may be seen in many worms. (2) Development is a sequence of changes in the course of which the qualities inherited from the two parents, and through them from ancestors, find expression or are hindered by other qualities from finding expression. But in this, as in the recapitulation, it has to be admitted that the developing organism develops as a unity, with a self-regulative power which baffles explanation (3) Development is the expression of the inheritance, but it requires an appropriate environment—of oxygen, moisture, warmth, food, and so on. Without the appropriate liberating stimuli of 'nurture' in the widest sense the inherited 'nature' cannot find expression, and many defects in the final result of development—arrests, abnormalities, malformations, &c.—are due to something lacking in the nurture, not to anything defective in the germ [J. A. T.]

Devil's Churnstick. See SPURGE.

Devon Cattle.—The Devon is one of the most beautiful, the most perfect (from the point of view of form and colour), and most economical of our British breeds of cattle. It has been divided, more especially during latter years, into two sub-varieties—those of the north and south of Devon respectively, but we shall see more of this later on. Although not so large as the other leading beef-producing breeds of England, the Shorthorn, the Hereford, the Sussex, and the Aberdeen and Galloway of Scotland, and also the black cattle of the Principality, it is equally as good in quality and frequently as fine in form as the best among them. A well-bred Devon contains a large quantity of meat in a small space, it may indeed be described as *multum in parvo*; both the top and under lines are level, giving the animal the blocky appearance which is so much respected by the butcher. As seen at Smithfield or Birmingham at the winter fat-stock shows, it is extremely handsome, especially when the coat is curled, either naturally or artificially—and it is usually the latter—for the inspection of the judges. The North Devon breed is not confined entirely to its native county or to Somerset, where many of its most prominent breeders live, but is well distributed over the entire country, owing to its constitution, its valuable properties as a feeder, and the uniformity of its size and colour. It is a rich deep-red, frequently flecked with white on the under lines, or near the udder in the cows. There is practically no history of the breed in which its origin is given; there are, it is true, hypotheses, but in the absence of any-

Photo G H Parsons

DEVON BULL—"TAPTON PLOUGHBOY"

1ST AND CHAMPION AT R.A.S.E. AND OTHER SHOWS 1908

Photo G H Parsons

DEVON COW—"WHIMPLE KITTY 1ST"

thing further it is impossible to make any attempt to ascertain how it was produced. It is sufficient to say that the breed exists, and that it is no new variety, for over a hundred years ago it was described by Arthur Young from information derived, according to Sinclair, from Lord Somerville, who stated that outside and eastward of a district which extended to a length of 45 miles and a breadth of 22 miles was a mixture of Gloucester, Welsh, and Upper Somerset . . . a varied dairy sample, but beyond the western extremity the Devon breed was found, but inclined to the Cornish type. Again, he remarks that the South Hams, or South Devon cattle, were found in the south of the county, and were a cross breed of uncertain properties with a good deal of white and brown, and black and white mixtures. It appears, too, that in Bampton in North Devon, and at Wivelscombe in Somerset, both of which are low-lying places, the breed was found very perfect. Young also points out that the breed was a confessed favourite and among the first at Smithfield, where prejudice cannot find a way. The mahogany shade of colour was apparently preferred, while the curly-haired cattle were regarded as excellent 'provers'. A glossy skin, paler or lighter, with curls like ripples of wind on a smooth millpond, was also regarded in the highest estimation.

Among the great breeders of the past were the Quartlys of Molland, in North Devon. The first of the line in connection with this breed, Francis Quartly, did as much for the Devon as Collings for the Shorthorn. According to Wallace, Francis Quartly was the great-grandson of James Quartly, who left Somerset in 1703, while others of the name subsequently flourished, and all were connected with the early production of the Devon breed. These men, like some of their neighbours, yeomen like themselves, were breeders of the best, and they sent to the markets of the district choice cattle, which it is possible might be admired at the present time. When prices rose in the early part of the past century, many of the best of the breeding stock of North Devon were sold, and it was then that Francis Quartly added to his herd many of the best cattle of the country, and by his care in selection and in breeding he was enabled to produce a herd which was raised to a position of comparative perfection. Quartly was a breeder of cattle for over forty years, and died at a great age about fifty years ago, having been, as it were, the maker of the modern Devon. It would therefore appear that from the beginning of the 18th century until the middle of the 19th, nearly 150 years, the Devon breed had been improving in the hands of the Quartlys, and during the whole of that period was regarded as a distinct variety of English cattle.

One of our early authorities on the Devon cattle was George Culley, who observed over a century ago that the Devons in the neighbourhood of Barnstaple were extremely pure, and that although they were red in colour there were others which were definitely marked with white spots, which was a sign of a stain in the blood. They were fine in bone, with horns bent upwards, thin faces and dun-coloured muzzles; they were wide in the hips, with a well-shaped but medium carcass, but a little flat-sided; they carried a thin silky skin, and a tail rather high, while they matured early; but what is still more remarkable, they were regarded as being well adapted to work on the farm. And yet we are also told by old authorities that, except for cleanness, quickness, and small size, they very closely resembled the Hereford. And so with the Sussex; although of a similar colour, they were smaller and finer in quality. But it must be remembered that, as is the case to-day, there were distinct varieties of the breed, and that distinction was much more marked a century ago.

The writer has for many years criticized the Devons at both the summer and the winter shows, such as the Royal, Smithfield, and Birmingham, and observed them in their store and their fat condition; he has also had many opportunities of seeing them in their native homes in North Devon, as well as in the south, and often found it difficult to reconcile the type, the size, and the quality of various sections of the breed. Professor Wallace, who has taken pains to collect evidence from breeders, quotes Polwhele, who speaks highly of the North Devon cattle, and who tells us that they carry a large quantity of flesh on very little bone. It is remarkable that in those early days the Devons were often crossed with the Guernsey, producing cattle which were very like their sires, but that when bred beyond the confines of the true Devon district their descendants of later generations were of inferior quality. The value of live stock in England was not at that time what it is to-day, for Polwhele remarks that such a price as thirty guineas was frequently commanded by the best males of the breed. Another writer expresses his belief that from the Devon cattle the Herefords, the Sussex, and the Gloucester Reds have been produced, and he believes that the Reds of North Devon in particular is one of our original breeds which has been preserved in its native form. He also quoted Bakewell to the effect that no cross alien to the breed would improve the Devon cattle, which for at least a century from the time—about 1800—had realized the best prices at the London market.

Mr. Samuel Kidner, one of the best breeders of to-day, writes us as follows: 'The Devons are one of the oldest breeds of cattle in the country, but have been chiefly confined to, and in the past little known beyond, their own district of Devon and West Somerset, so far as their breeding is concerned; they are, however, much sought after and appreciated for grazing purposes in more distant counties, where they never fail to give satisfaction as being hardy, thrifty, and producing the very best quality of beef. If we go back from twenty to forty years there was a certain distinction in Devons bred in different districts, although all were blended with the same blood; this distinction was chiefly found between those of extreme refinement, with consequently smaller size and wealth of flesh, bred in North Devon, and those of West Somer-

set, which with size, wealth, and hardihood still maintained a beauty of character unsurpassed by any other breed. These distinctions, under the influence of the Devon Cattle-breeders' Society and their periodical shows and sales, have now been almost entirely broken down, and the latter type may be said to prevail as representing the best characteristics of the breed. In their own district they have held the field against all-comers, and where other breeds have been tried from time to time they have in almost every case given place to the old habitants. So far as their dairy properties are concerned, where these have been cultivated the results are eminently satisfactory, and many dairies may be found in Devon and Dorset where the dairymen have no wish to change to other breeds. This class was well demonstrated at the recent show of the Bath and West of England, where classes were given for dairy cows of the Devon breed, and the Devon Cattle-breeders' Society have in hand the popularizing of their breed for this purpose. Of recent years a growing demand has sprung up for exportation to foreign countries, and their advocates believe they only need the one advantage of being better known for this demand to increase to a very much greater degree, as the accounts gathered from their distant homes are all that could be wished or has been claimed for them. They have in recent years found friends in different parts of our own country, and are, so far as can be learnt, giving every satisfaction, maintaining their thrifty habits, beauty of character, and high quality. In Uruguay and South America generally they are gradually gaining a footing, and many have been exported to those parts. The Japanese, with their usual shrewdness, are importing them in large and increasing numbers. Australia and New Zealand are making active enquiries, and in smaller numbers they are being exported to nearly all cattle-breeding countries.'

I once remarked that the Devons had been called into existence to fulfil a particular and in some respects peculiar purpose, and, as far as it is given to us to judge, they are not to be found wanting. The localities in which the breed is most common, the climate to which it is exposed, and the requirements of the men who profit by it, combine toward a certain end, and in the Devon cattle these influences have worked together with a most satisfactory result.

Devon cattle possess a type of their own, and yet there is probably no breed in which individuals of almost precisely similar general aspect will, when scrutinized and analysed carefully in their several features, exhibit more marked variations. In size they are medium, although it is a common custom to speak of the 'little Devons'. They do not possess the bulky appearance of the Shorthorn or the Hereford; and yet they are far from being a diminutive breed like the Ayrshires or the Channel Isles cattle. The general aspect of the Devon is graceful, and its appearance indicates a gentleness of mien which their looks do not belie. The head is small, but the forehead comparatively broad, tapering off to a neat, clean-cut muzzle. The ears are thin and soft in texture, the eyes bright, and do not exemplify the dreamy look which so many breeds possess. They should be encircled by a ring of light colouring, almost approaching an orange hue. The nose should be white. The horns are of medium length, graceful, and spread in an outward and upward direction, tapering easily off. In the male this feature is scarcely exemplified to the extent that it is in the female.

The outline of the Devon should not exhibit any very marked divergence from the proverbial parallelogram which should be realized in fat beasts. The neck is full but lengthy, and should show a good wedgelike form when regarded end on. The chest is deep and prominent; wide fat loins, and a well-filled rump, where plenty of beef may be piled up, constitute one of its best points as a butcher's beast. The legs are fine, but well set on. The bone is small, but the frame is, notwithstanding, but comparatively speaking, large. Red is the colour of the Devon, although a large number of the cattle in Devonshire display some white about them. The skin is fine and mottled. Much depends on the soil and the climate—for larger size is attained where the pastures are rich, as in those parts of Somerset where the Devons thrive so well. On Dartmoor and Exmoor, where there are also many herds of the Devon breed, not only is the food much poorer, as might be expected, but the climate is more severe, and the consequence is that unless they receive artificial food in sufficient quantity the size is smaller and the quality inferior. South of Dartmoor and along the coast to Dorset there are large numbers of Red Devons of good size which are excellent milkers, and which have long been bred for this class of production.

Devon cattle have been grouped under three varieties—the North Devon, the South Hams, and the Devon proper, but it is obvious that there is little or no difference in the blood. The North Devons are the smaller and finer variety. Their coat is softer and more curly, and their general appearance more nearly warrants them being termed 'the little Devons' than does either of the other two more distinctive varieties. The South Ham cattle—that is, the cattle bred upon the fine uplands which lie between Dorset on the south-east, the sea on the south, and Cornwall on the south-west of Dartmoor, which forms the centre highland of the county—are fine beasts, coarser in appearance and of bigger bulk than the North Devons. The Devons proper may be said to combine the most notable features of these two varieties. They are found mostly in the district round Taunton, and in Somerset and Dorset, and are well represented, as a rule, at the Smithfield show, where they are apparently the embodiment of the standard of excellence for the breed in general. Besides these, both Exmoor and Dartmoor, the latter in particular, produce a rougher type of smaller size and coarser bone and flesh than do the other less exposed parts of the country.

Special Characteristics. — The merits of the Devon are many. They are as profitable a meat-producing breed as any in England. Given so much food, the percentage of beef returned

is as large as can be shown by any other breed. The beef is of prime quality, the offal proportionate, and the bone small. As fatteners they are not to be surpassed in their own country, and will go from store to fat beasts quickly on good pasture and a little artificial food. They require no severely expensive nor extensive course of fattening. As dairy cows they are more noted for the quality than the quantity of their produce, but it must not be supposed that the latter is small. When we remember that they are producers of clotted cream and milk and perfect butter, that should be quite sufficient. One hears of great Jersey and Ayrshire records, but there is little doubt that were Devon records as persistently and carefully placed before the public, they would take a high place in the ranks of our dairy breeds.

'I will not confine my remarks', says Mr. Perry of Lewdown, North Devon, 'to strict data, but rest them rather on general or natural laws and principles and broad results, because from the various and varying conditions which must be brought into play to produce the developed animal, arising from different treatments and situations, strict or narrow data are more often misleading than otherwise. In the first place, I hold that small- as well as large-sized animals are needed to turn our various cattle foods to the best account for the production of the best supply of animal food for the people. All producers cannot raise the foods required for the proper development of large-sized animals, nor are large-sized joints of meat suitable to all households. Again, small animals can be brought to perfection on pastures which will only keep large animals in store condition, and when fodder is scarce the small animals will pick their food in sufficient quantities, while the large will starve; and if wanted for the market, the former can in a few weeks be fattened on concentrated foods, before one's eyes, whereas a large animal must have its time. There is this, however, to be said of large-class animals: if their owners can keep them fattening from birth, they must, to have heavy weights at an early age, have the property of rapid growth.

'My conclusion is that an animal which is right in form, quality, and constitution is a first-class one, whether it be large or small in size, and it therefore remains for those who have them to place them in suitable situations for foods and markets. I have often found that small-framed animals make me the most money, and my motto is to have an animal that will *swell*, rather than grow, into value.

'From fifty to sixty years ago, Shorthorn cattle were introduced into Cornwall by a Mr. Peter, and they spread over a large part of the county, fixing themselves more particularly in the best districts. They also found their way into Devonshire and Somerset, where they have had rather an extensive hold, but of late the Devons have been hedging them rather closely into the most fertile spots of the country, and many who were zealous advocates have either partially or wholly given them up. Herefords also found their way into Cornwall about the same time, and were extensively kept in the eastern part of that county by a few other breeders farther west, but they have nearly disappeared from the east, and are in few hands in the west of the county. They are no favourites with the butcher, having too much rank spine or fat, and killing hollow and deceptive in their weight. The North Devons are now entering into the strongholds of these breeds, and are becoming the most general breed in the west of England. Their flesh is more marbly and mixed than the before-mentioned breeds, and their meat, as a rule, is of finer texture, more firm, and of superior flavour. They may be divided into two classes, the North Devon and the Somerset Devon. The former is a smaller animal than the latter, more handsome, and more easily fattened. They are particularly adapted for hilly districts, where they will frisk about with pleasure, and do well on short pastures, and with a little indulgence for a few weeks will be fit for the butcher, nothing in the way of beef selling at a higher price per lb. Animals of this breed that are fit for slaughtering at 5 cwt. may be made 8 to 9 cwt. with extra feeding.

'The Somerset Devon is a larger animal than the genuine North Devon, and from having been crossed with the latter sometimes grand animals are produced. As a specimen, for example, I may name Kidner's Islington champion ox. It is certainly important that the North Devon should be preserved, for then crosses may be taken as people wish; but if the pure race is lost it cannot be recalled, and a crossbred cannot be depended on to stamp its character on its offspring. The well-bred Devon is not, as a rule, a great milker, but the quality of the milk is rich, and 1 lb. of butter per day may be considered a good average. Well-bred animals are often kept in the dairy, though they fail as milkers, simply on account of their value as breeders; but this is not the case with mongrels, for if they fail as milkers they are at once fattened. On this account, mongrels are often stated to be better for the dairy than they really are. The Devon breed occupies, with but slight exception, the whole of the district north of the forest of Dartmoor to the Bristol Channel, including the forest of Exmoor, and from West Somersetshire through Devonshire and Cornwall it holds the principal sway. I consider the fact of the Devon cattle again taking possession of the strongholds of the other breeds, to be a broader and much more trustworthy fact as to merit than any test made on a small scale. The Devons were first bred on the Government prison farm at Dartmoor, then the Ayrshires, then the Polled Scots, and now the Devons have again taken up the position which they held at first.'

'In speaking of the Devons it must be remembered', said Mr. John Surridge—another successful breeder—to the writer, 'that there are the Somerset Devon and the North Devon breed. I have been breeding principally Somerset Devons. I have never kept an account of the average yield of milk, but some of the Devon cows give from 16 to 18 qt. per day, and make from 1 to 1½ lb. of butter daily, while others

give not more than half that quantity. The live weight of a Somerset Devon at four years of age reaches from 18 to 22 cwt., and my own bred bull Robin at four years old weighed 1 ton 56 lb., and the dead weight was considered 80 score. The cows weigh from 12 to 17 cwt. live weight; oxen from 15 to 20 cwt.; steers under two years old, 8 to 10 cwt.; steers under three years old, from 12 to 15 cwt., and steers under four years, from 13 to 17 cwt.

'The grasses cultivated are Dutch and Alsike Clover, Trefoil, and Italian Rye Grass. I myself cut some for hay; others cut some green for feeding in summer. If the animals are intended for exhibiting, the system of housing pursued is to keep them in during both summer and winter, giving them every day moderate exercise, and feeding them on different kinds of meal, cake, root, and green food. I commence handling and leading when my beasts are about three months old, but sometimes before. The dead weight of one of my animals was 144 st. 5 lb., or 57 score 17 lb., and her live weight 14 cwt. 1 qr. The temperature on my farm is about 60 to 65 in summer, and 45 to 50 in winter, and the soil in my neighbourhood is chiefly ray and sand, some of which is very good and some very inferior.'

'My uncle', says Mr. Richard Bickle, of Bradstone, a famous Devon breeder, 'has been a breeder of Devons for upwards of forty years, and I still retain the same herd. I have always found them more profitable than any other breed, both for milk and aptitude to fatten. I can keep three Devons to two Shorthorns, and I find they will stand the winter and our wet climate far better than any cross- or pure-bred animals, and that without any housing or extra care. I have 125 bullocks, chiefly Devons, but I find the best bred ones are preferable to be kept, as they are always fit for anyone to look at. During the summer I graze upwards of 100, besides my regular stock, and consequently I sometimes get a Shorthorn, Hereford, or cross-bred animal, but I invariably find it does me no good.

'I have never tested the milking properties of the Devon, but they are not heavy milkers as a rule, although the cream is of the richest quality, and will make more butter than that from almost any other breed. We never make cheese in our county, as it is not one for cheese-making. The average weight of my cows with ordinary feeding would be about 7 cwt. of marketable beef, steers being about the same at three years of age. I have had some of the latter which weighed as much as 13 cwt. at four years old. Bulls in proportion weigh just the same.

'The chief part of my farm is a light soil, with grey freestone, and the temperature is very changeable both in summer and winter. We have plenty of rain. As the district I live in is a grazing district, the grasses used are of an ordinary character, just for three years ley. The Devons in my immediate neighbourhood are not used for draught purposes, but in the neighbouring county of Cornwall I have heard of several being so used. My uncle had oxen in constant work many years ago, and they were considered better workers than any other breed. My young stock, as a rule, are housed about the beginning of November, but it depends partly on the mildness of the season. Store ones have an open shed all the winter.'

It will be noticed that much has been said about the varieties of the Devon breed, but it will be acknowledged by all who have experience as breeders that the same breed of cattle varies not only with the climate in which it lives, but with the grass upon which it feeds. The Kerry of the mountains in the south of Ireland is quite a different animal to the Kerry which is fed upon rich pastures in England, and so with every breed. There is little doubt that all the Devons of the west have descended from the same parent stock, and that what differences there are are owing to the causes we have mentioned. Mr. Risdon, who has a wide and extensive knowledge of Devon breeders, holds the same opinion, and maintains that if large-sized cattle of any breed are required they must be kept on rich and abundant pastures, or their food must be supplemented by corn, cake, or some other nutritious diet. From this gentleman, who acts as the secretary of the Devon Cattle-breeders' Society, I am indebted for the following particulars, which confirm what has already been stated.

'That climate and soil exercise a perceptible difference in the size and formation of animals is generally admitted by all careful breeders.

'The weight which Devons attain with ordinary feeding would be, with cows, from 30 to 40 score lb.; steers, at about three years old, grazed for the Christmas markets, would scale from 40 to 50 score; the favourite weight, and which generally commands the best price, is from 40 to 44 score. Individual animals of this breed have attained to far greater weights than above quoted. Mr. John Bull has a cow fed on grass, hay, and roots only, which weighed 1448 lb. Mr. J. D. Hancock had an ox which at five years old weighed 1788 lb. Mr. Thomas Oatway had an ox which scaled 1714 lb., and Mr. George Risdon had one which at four years old weighed 1648 lb. These weights are of the dead carcass. It should further be stated that none of these oxen received artificial food for more than three months previous to being slaughtered.

'In years gone by, there was a very marked difference in the various types of the breed. That of the North Devon, such as were bred by the Messrs. Quartly, Davy, and many others in the localities of Molland and North Molton, are now owned in anything like purity by but very few breeders. The use of bulls of this variety on the larger size cattle known as Somerset Devons has had a refining effect on this variety of the breed, such as used to be bred of great size in the Vale of Taunton Deane, and other localities where the land is rich. It would be hard to find at present a herd which had not had North Devon introduced in a greater or less proportion.

'There are large herds of Dorset or Dairy Devons kept in Dorsetshire, as well as in some other localities where dairy properties are

valued. From long and careful selection of both males and females this breed proves eminently satisfactory for dairy purposes, and these will hold their own in competition with most other breeds. It has been asserted that the original home of the breed is on, and at the base of, the Forest of Exmoor. There are at present many good herds in the Dartmoor locality, amongst them that at the Government Prison at Princetown. In the past, good herds were kept in Leicestershire by the Earl of Leicester and others, by H.M. the King and Mr. John Walter in Berks, by the Earl of Aylesford and Messrs. Umber in Warwickshire, by Mr. Wm. Childe of Kinlet Hall in Shrops, by the Earl of Dartmouth in Staffordshire, by Messrs. Wilkinson & Barrington in the Isle of Wight, and by Miss Rose and Mr. Peek in Ireland. They are also found to do well in both North and South America, Australia, South Africa, and Japan, as well as on the Continent of Europe. Large numbers are now being exported, chiefly to the countries above named, and most satisfactory accounts of their suitability and usefulness in these countries are being frequently received. I know of only one herd of Devons in the north of England, and of none in Scotland; there are, however, a good many herds in the midland counties.'

One of the finest herds of milking Devons in England, and perhaps in the world, is that owned by Mr. William Vosper, of Plympton. This herd consists of some 200 head, and of late years some have been exhibited by Mr. Vosper in milking classes at the larger shows. If we may be guided by the success which Mr. Vosper has achieved, and from what we have seen of his extensive farm and his dairies, we should say that no breed of cattle in the country could have served him better. The milk is raised upon the Devon system, largely for the sale of clotted cream, which is sent to Plymouth. In each dairy there appeared, when we saw them, to be several scores of pans covered with the richest cream that could be produced, not excluding that of the Channel Isles breeds. [J. Lo.]

Devonian System.—The marine beds of this system are those usually known as Devonian, while the freshwater deposits are classed as Old Red Sandstone. Both types were deposited in the Britannic area during the Devonian period. In our islands the marine beds occur in Devonshire and Cornwall. In Devonshire we have, north and south of the Culm-measure region, Devonian slates and sandstones, with a fine grey limestone appearing in the middle of the system in the southern area. Plymouth is largely built of this stone, which is freely burnt for lime. Climatically and geologically, the south is the richer side of the county. The Devonian rocks of the north form the wild lands of Exmoor, barren above, but cut into by steep-sided valleys or combes, in the shelter of which trees flourish. Through Cornwall the 'killas' or slaty type of beds prevails, forming a somewhat dreary country, swept in the west by the Atlantic winds. Granite intrusions occupy large areas.

The Old Red Sandstone presents very varied features. It forms the rich lowlands of Herefordshire, the wooded but almost highland zone from Dumbarton to Montrose, and the bare grey rocky masses of the west of Cork and Kerry. Fine-grained grey to red sandstones, with some conglomerates, prevail along the north side of the South Wales Coalfield, rise in heather-covered moors round Brecknock, and yet form almost a plain eastward, from the back of Wenlock Edge through Hereford and Monmouth to the Severn estuary. The most notable irregularities of the surface in this last-named district are produced by Carboniferous outliers, or by inliers of Silurian or older rocks. The fertility of a large part of the triangular area of Old Red Sandstone east of Brecknock arises from the frequent occurrence of *cornstones*, or concretionary masses of grey limestone, in beds which are practically marls. The variety of material that may here accumulate along the river flats furnishes a rich alluvium.

In Scotland, a Lower Old Red Sandstone series graduates downwards, through barren sandy *Tilestones*, into the Silurian rocks of Lanarkshire, while an Upper series rests unconformably upon it and on all the earlier strata.

The Old Red Sandstone of the Cheviots and of the Ochil and Sidlaw Hills is largely modified by the presence of andesitic igneous rocks. As in South Wales, the relative elevation of various parts of these tracts has considerable influence on their value as agricultural lands. It may be taken as general, however, that the somewhat rare marly beds yield good farmlands, while the typical red sandstones and conglomerates are given over to peat, heather, and forest. Cornstones occur in the Scotch Lower Old Red Sandstone. On the geological maps of southern Scotland, numerous bands and outlying patches of Upper Old Red Sandstone may be seen lying unconformably across Silurian strata, and this fact accounts for abrupt changes in the character of the surface materials. Often, however, the detritus from the Old Red Sandstone affects beneficially the stiff clays of lower lands.

North of the great band of Old Red Sandstone that occupies the south-east of Forfarshire and Perthshire and the north-west of Stirling, the same rocks reappear on both sides of the Moray Firth, and purple sandstones run up, as a south-west extension, along both shores of Loch Ness. Caithness and the Orkneys owe their comparatively level surface, in contrast with that of the adjacent Dalradian highlands, to the flaggy Old Red Sandstone strata, which here form an almost treeless country, the soils of which are suitable for cereals.

In Ireland, the Old Red Sandstone forms an upland region with red soils between Lough Erne and Cookstown, the surface of which is modified by thick glacial drift. It reappears frequently from under the Carboniferous series throughout the country, occasionally forming high moorlands, like the Slieve Bloom Mountains and those about Lough Derg. But in these uplands there is usually a core of Silurian rock, where tillage is carried on, while the surrounding sandstone remains uncultivated. The wildest country produced by the Old Red Sand-

stone lies in the west of Cork and Kerry, and the great earthfolds of this rock spread thence eastward, with hollows of Carboniferous Limestone and Slate between them (see art. CARBONIFEROUS SYSTEM). Trees have been successfully planted on the slopes of many of these moorland ridges throughout Cork and Waterford. The downwash from the sandstone mingles ad-

Sketch Map of Devonian System.

vantageously with the clays along the limestone hollows, though here and there a sandy alluvial cone from the valley side may spread itself unduly across the lowland.' [G. A. J. C.]

DEVONIAN AND OLD RED SANDSTONE SOILS.—While the marine and lacustrine deposits of the Devonian system are somewhat different in character, the soils derived from them are fairly uniform in type, and, where the accident of elevation does not count against them, they enjoy a very high reputation for fertility. The

typical soil is a dark-red stony loam, somewhat stiff to work, but on the whole very suitable for tillage. In the districts where limestone bands occur associated with the Devonian rocks, the land is highly productive and ranks with the best in the kingdom. This is well seen in the 'cornstone' soils of Herefordshire, and in the soils of the South Hams area of Devon.

Turnips and potatoes do remarkably well on the soils of this formation, and exceptionally large crops of mangels can be grown on them, if the land is well cultivated and generously manured. These soils are likewise favourable to the growth of barley and wheat, and the latter crop can be raised farther north and at a higher elevation on the Old Red Sandstone than on any other formation. The oats sown on the richer lands of the Old Red Sandstone are liable to become 'lodged' or 'laid' from a too luxuriant growth; this is the case especially in the districts of high rainfall, as in the South of Ireland, where the writer has frequently seen the crop suffer much damage from this cause.

As grasslands, those of the Devonian system are generally excellent, but except in the richest districts the pastures begin to degenerate a few years after being laid down, and require to be renewed at comparatively frequent intervals. The Devonian pastures seem to be peculiarly adapted to the production of butter. It has been pointed out that the highest grade creamery butter in Ireland comes from the Old Red Sandstone districts, as those of Tyrone and Cork (Kilroe, The Farmers' Gazette, April 14th, 1906). The butter and cream from the corresponding formation in Devonshire enjoys a similar reputation in the London markets.

The lowest Old Red Sandstone or Tilestone series yields exceptionally poor thin soils which are often left uncultivated. Such soils appear in parts of Lanarkshire, Caithness, and Shropshire. The Old Red Sandstone conglomerate, which may be seen associated with the tilestones of the last-named county, produces a gravelly to loamy soil of a very poor description.

In Hereford, Monmouth, Shropshire, and the south of Ireland, where the cornstones prevail, the soils, as has been already stated, are very productive. The magnificent pastures of the first-mentioned county have developed the celebrated breed of Hereford cattle, renowned all the world over for its beef-producing qualities, and the cultivated areas of that county enjoy an equal reputation for their cider and perry. Of forest trees, the oak is the most widely distributed, and appears to be a natural product of the district. Hops are cultivated in some localities, and wheat and barley are pretty generally grown.

In South Hams, 'the garden of Devonshire', the soils on the marine Devonian consist of rich calcareous clays and light loams, which produce excellent crops of barley, wheat, oats, beans, turnips, and potatoes. These fertile conditions prevail over a wide tract of swelling land with rich vales extending from Plymouth to Torquay, and as far north as Dartmoor. The lower levels of the Devonian system in Cornwall seem to be specially adapted to the culture of potatoes, and near Penzance, and in the valleys of the Looe and Tamar, a very considerable quantity of them is grown. Early potatoes can be lifted in May or earlier in these districts. The mountainous parts of the formation in Cornwall are very unproductive.

The Old Red Sandstone soils in East Lothian, such as the red soils of Dunbar, are justly celebrated for their fertility, and for the character of the farming of which they form the basis. They are amongst the highest rented lands of the British Isles, and may be described as suitable for all crops. In Berwickshire, the Old Red Sandstone formation produces a dry free-working sandy or gravelly soil, which is well adapted to the cultivation of turnips. Many of the Old Red Sandstone soils of Caithness are modified by drift; they vary from clays in the northern part of the county from Forss Water eastwards, to a dark loam west of Forss Water, and in the north-eastern portion of the county. Wheat and barley are largely grown on these soils, and on those of the Old Red Sandstone country round the Moray Firth. The lands of the Upper Old Red Sandstone series are usually hilly, and the soils poor and often wet. Much of this ground is covered with heaths and bogs.
[T. H.]

Devon Long-woolled Sheep.—This breed is one of great antiquity, and has always been associated with the western counties of England. Like most other ancient breeds, it is particularly suited to its native soil. No one has yet been able to assert its origin, but the name is stated to have been derived from a village on the borders of Devon and Somerset, where the sheep are supposed to have been first bred.

In Youatt's Complete Grazier, these sheep are thus described: 'The Devonshire polled sheep form two distinct varieties of the same breed. The Devonshire Nott, with brown faces and legs, a crooked back, flat-sided, coarsely boned and woolled animal, carrying a fleece of 10 lb. average weight, and the mutton averaging 22 lb. per quarter at thirty months old, has been crossed with the Leicester and converted into 'the Bampton', with white faces and legs, round chested, smaller boned, and the wethers, at twenty months old, averaging as much weight of carcass as the others at thirty. They are not, however, equally productive in weight of wool, but that is longer, finer, and far more valuable.'

Another early writer describes them thus: 'They are the best breed in Devonshire, and have existed in the neighbourhood of Bampton from time immemorial. A fat ewe of that breed rises to 20 lb. a quarter on an average, and the wethers to 30 or 35 lb. a quarter at two years old. They are whitefaced, more like the Leicestershire than any other, but larger boned and longer in the legs and the body.'

It is a well-known fact that this breed, like almost every other variety of long-woolled sheep, has been greatly improved by judicious crossing with Leicester blood, and it is possible that crosses with other long-woolled breeds may also have been made. The following advertisement

may prove interesting, and it will at least serve to show that some old breeders, when making such crosses as above referred to, were very careful to select rams, not only of good appearance, but which had also been well bred:—

TO BREEDERS OF SHEEP

TWO CAPITAL NEW LEICESTER RAMS

By Mr. Stone's L., a son of Dishley L.; grandson of G. Dams, by Stone's R., son of Dishley K. A few Ewes will be taken in to run the next season with these Rams, by applying soon to Mr. Richard Gooding, Morebath, Devon, at two guineas each ewe and threepence per week for keep.

Dated June 28th, 1802.

It is undoubtedly true that, in the past, sheep of this breed attained a great weight. This is shown by the following: 'Early in the last century Mr. George Turner, of Thorverton, near Exeter, had forty two-year-old wethers, whose carcass weights were estimated at 40 lb. per quarter each. Sometime in the 'fifties, Mr. John Oatway, who farmed in the parish of Old Cleeve, Somerset, sold the whole of his shearling wethers (but two) at 27 lb. per quarter on an average. In 1858 Mr. John Bird, of Volis, near Taunton, sold about four-fifths of his shearling wethers (after selecting about twenty of the best lambs for rams) at an estimated weight each of 28 lb. per quarter. The wethers belonging to Messrs. Oatway and Bird were as nearly as possible from fifteen to sixteen months old, and neither they nor Mr. Turner's sheep had been fed on any description of corn and cake, and the prices which they were sold for were, in accordance with the estimated weights, at the current market value per lb.'

Two other records of the extraordinary weight of sheep of this breed are as follows:—

Spooner, in his History of Sheep, states that a wether of this breed, slaughtered in 1835, weighed no less than 70 lb. per quarter.

Mr. J. J. Walker, writing to the Meat Trades' Journal, says: 'I beg to give you particulars of two sheep, a wether and a ewe (twins), bred and fed by Mr. Thomas Kingdon, of Thorverton, Devon, and slaughtered 28th March, 1846. The wether's enormous weight was 78 lb. per quarter, or 39 stone (8 lb.), being the heaviest sheep ever killed in Her Majesty's dominions. The ewe's weight was 57 lb. per quarter, or 28½ stone (8 lb.).'

As regards the weight of wool, fleeces (washed) from shearling ewes and wethers, which have been shorn as lambs, weigh from 10 to 11 lb. on an average. Shearling rams, shorn as lambs, with ten months' growth of wool, would give fleeces from 15 to 18 lb. each; occasionally, with twelve months' growth of wool, rams will clip fleeces of 23 to 24 lb. each.

During the 'sixties, certain Long-woolled breeders introduced Leicester rams into their flocks and attempted to palm off the progeny as improved Leicesters. The sheep thus produced were successfully exhibited, and for a time became fashionable, and a large number of rams were disposed of. It soon, however, became apparent to those who bred from them, that their stock was deficient in muscle or lean meat. This cross proved disastrous to a good many flocks, and but few breeders had resolution enough, when they found their error, to discard the whole of them from their flocks. The majority, finding the mistake they had made, instead of reverting to breeders who had maintained the flesh in their sheep, for rams, procured Down and other rams, which they used on their Long-woolled ewes. The ewes of this breed are generally good mothers, the lambs coming strong and getting quickly on foot, and are easier to rear than those of most other breeds.

The first society to offer prizes for this breed of sheep was the Bath and West of England Agricultural Society, which they did at their show at Taunton in 1870. Since then, Devon Long-woolled sheep classes have been instituted at all the principal shows. In 1898 the Devon Long-woolled Sheep-breeders' Society was formed, for the purpose of furthering the interests of the breed. A flock book has since been established, the first volume of which was issued in 1900, in which were registered 22 flocks, containing rams No. 1–453 and ewes No. 1–47.

A good many rams of this breed have been exported to the Argentine and Australia, in both of which countries they give entire satisfaction.

The rams are usually sold as yearlings and command good prices, some being sold at from 40 to 50 gs. each. In some cases they are let for the season at prices ranging from 15 to 30 gs. for good animals. [J. RI.]

Devonshire Cream. See CLOTTED CREAM.

Devonshiring or **Denshiring.**—Primarily a method of cleaning land, especially old pastures, which are apt to become overrun by weeds. In this practice, the first 2 in. or so are removed by the paring plough, and the parings, after being collected in heaps to dry, are burned. See also PARING AND BURNING.

Dew.—Until about the beginning of the 17th century, scientific men held the opinion of ordinary observers that dew fell from the atmosphere. But, in 1642, Nardius of Florence defined it as an exhalation from the earth. A century ago, Dr. Wells held firm to the theory that dew was condensed out of the air near the surface of the earth. Dr. John Aitken in the 'sixties carefully studied the subject, and came to the conclusion that dew is mostly formed of vapour rising from the ground. He was struck with the unvarying fact that the ground, a little below the surface, was warmer than the air over it. By placing a thermometer among stems below the surface, he found that it registered 18° F. higher than one on the surface. Vapour must, therefore, rise from the ground and mingle with the air which it enters; and its moisture will form dew whenever it comes in contact with a cooler surface. Take a thin metal tray, and place it face downward over the ground before sunset. On dewy nights, the *inside* of the tray is dewed, and the grass inside is wetter than that on the outside. The vapour rising from the ground has been trapped by the tray. If the

Photo G H Parsons

DEVON LONG-WOOLLED RAM

BREED CHAMPION AT ALL THE LEADING SHOWS IN 1908

(63)

Photo G H Parsons

DEVON LONG-WOOLLED EWES

1ST PRIZE WINNERS AT R.A.S.E. SHOW, 1908

tray be placed on bare ground on a dewy night, the inside of the tray is quite wet. Farmers of stony soil are quite aware of the necessity of keeping some of the stones on the surface, that the dew might be caught by these, when rising from the ground. Around old implements in the field there is a very marked increase of grass, owing to a deposit of moisture near these articles, moisture which has been condensed by the cold metal from the vapour-charged air which has risen from the ground on dewy nights. The theory is better tested in the case of hoar frost, or frozen dew.

What is called dew on plants is generally not dew at all, but the moisture exuded by the plants in a state of health. The drops are formed all round the leaves, at certain definite points near the tips of the blades. These large drops—once called 'dewdrops'—are merely the watery juices exuded by the plants. Remove a branch of poppy and connect it by means of an india-rubber tube with a head of water of about 40 in. Place a glass receiver over it; and in a short time the leaves will be quite wet. If the water pressed into the leaf is coloured with aniline blue, the drops when they first appear are colourless; but before they grow to any size the blue appears, showing that little water was held in the veins. The whole leaf soon gets coloured of a fine deep blue-green, like that seen when vegetation is very rank. This shows that the injected liquid has penetrated through the whole leaf. Examine Broccoli during rain, and the surfaces of the leaves never seem to be wetted by the water. The raindrops glide off their surfaces 'like water off a duck's back'. [J. G. M'P.]

Dewberry (*Rubus cæsius*, L.) is a species of bramble with stems spread out along the ground, found in open fields and stony wastes, also in hedges and thickets. The fruit is readily distinguished from that of bramble by the presence of a 'bloom' or fine coating of wax (*glaucous*), and by the comparatively small number of pips or drupelets per fruit. [A. N. M'A.]

Dew-ponds.—This name is given to ponds constructed on the high down lands of Wiltshire, Sussex, and other counties. They are made in such positions that they do not get filled by running surface water, as is the case with ponds on lower levels, but obtain their supply entirely from the rainfall and dew. It has been a constant theme of wonder how they retain water so long, and supply so many sheep during a time of drought. Rudyard Kipling describes those he saw in Sussex in this quaint and pretty rhyme:—

'We have no waters to delight
Our broad and brookless vales—
Only the dew-pond on the height
Unfed, which never fails,
Whereby no tattered herbage tells
Which way the season flies—
Only the close-bit thyme that smells
Like dawn in Paradise'.

Experience has shown that they maintain a supply of water for sheep and other stock in a most remarkable manner in periods of prolonged dry weather when other water holes fail, but no carefully recorded measurements have been taken to show the amount supplied by the dew, which gives to these ponds their distinctive name. It is impossible to say when they were first made. Some have given them a Neolithic origin, but the evidence of that is more imaginary than real. It is certain, however, that about one hundred and fifty years ago they were being commonly made to supply sheep with water on the hills of Sussex and Wiltshire during the summer months. Since that time, dew-ponds have been made by landowners and occupiers of farms. The technical skill for the making of these ponds has been confined to a few families. The Smiths of Market Lavington, in Wiltshire, have for generations been acknowledged experts in the art, and have made many on the estates of the Duke of Rutland, of Lord Wantage, and of other noblemen. The mode of construction is as follows. The highest part of a down is selected, and the soil dug out and removed for a space of 20 or 22 yards square, or in diameter, and sloping down to a point, the total depth at the centre being about 7 ft. As the subsoil is nearly always chalk, a firm foundation is readily obtained. Some prefer that the ponds should be circular, while others like them square in shape. For an excavation of this size some 200 to 250 cu. yd. of soil must be removed. When this has been done, clay is well puddled over the whole surface. The thickness of the coat depends upon the quality of the clay and the nature of the bottom of the future pond. Red clay is the most suitable. The depth of the clay is usually from 5 to 6 in. The durability of the pond largely depends upon the way in which the clay has been beaten. Above this coat of clay is placed a layer of lime, mixed to the consistency of a paste, and spread evenly over the whole surface. This is to prevent worms perforating the clay and to preserve it. Two hundred and twenty-five bus. of lime will be necessary for a pond of the size mentioned. Over this is evenly laid a layer of wheat or rye straw of good quality. Two tons of this material are required, and over the straw pieces of chalk or rubble, of sizes varying from a walnut to a cricket ball, are carefully placed to the depth of from 14 to 16 in. The straw is to prevent the chalk or rubble breaking the waterproof face of the clay, and to protect it from the heat of the sun or from frost, until the clay and lime have well set and the pond has gradually filled. Horses and cattle should not be allowed access to these ponds, unless they are fenced in and a specially prepared drinking place is made, otherwise they will, with their heavy weight, press through the clay. It is equally important that crowbars or other pointed implements should not be used to break ice in the winter, and that docks and other weeds should not be allowed to grow to the detriment of the foundation. The expense of making varies according to the facility of procuring and carting the necessary materials, but for those about 22 yards square, the cost is from £120 to £125. As they are usually constructed at elevations varying from 800 to 1000 ft. above sea level, where no other water supply is available, it is clear that they must be of

immense advantage to sheep-farmers. When properly constructed, and when reasonable attention is paid to their preservation, there is abundant evidence that they maintain a sufficient supply of water for sheep, even in periods of deficient rainfall. [E. BL.]

Dewsland Cattle. See WELSH BLACK CATTLE.

Dexter Cattle, a breed of cattle indigenous to Ireland. See IRISH CATTLE.

Dhoura. See DURRA.

Diabase.—This name was usefully revived by Hausmann in 1842 for a series of altered chloritic 'greenstones of various grain and structure. The older diorites, dolerites, augite-andesites, and even basalts, may thus become diabases, the typical rock being tough and greenish-grey, with dull but resisting lime-felspars and softer and chloritic iron-magnesium silicates. Hence the resulting soils are much like those on diorite, and are far more fertile and rich in lime and phosphoric acid than the more sandy soils derived from granite. [G. A. J. C.]

Diabetes. — The passing of an excessive quantity of urine, and at frequent intervals, accompanied by an abnormal desire for water, is commonly spoken of as diabetes in animals. An important distinction is drawn between this malady, which by veterinarians is called polyuria or excessive staling, and the disease of true diabetes, in which sugar is a constituent of the urine. The former disease is scientifically designated *diabetes insipidus*, and the latter *diabetes mellitus*. Horses and dogs are very liable to the simpler form of the malady, and dogs occasionally suffer from the mellitic, but in the domesticated animals generally it may be said to be very rare.

The causes of profuse staling are generally associated with dietetic errors, and frequently traceable to mowburnt hay, kiln-dried oats, or other damaged forage, as frosted roots given to cattle and sheep. The symptoms, in addition to that already referred to, are thirst, hidebound, or loss of gloss in horses' coats, and disposition to coming out of the wool in sheep, capricious appetite, feeble pulse, pallor of the visible membranes, loss of flesh, sweating with but slight exertion, and sour-smelling breath.

Treatment.—Horses are given a mild aloetic dose as a preliminary measure, and a suitable laxative may be advised for other animals; the food being changed to that of a demulcent character, as linseed tea, bran, scalded oats. The drugs having a reputation for this disease are iodine, iron, nux vomica, quinine, calumba, and dilute nitro-hydrochloric acid. Besides a liberal diet of the best, pure air and moderate exercise are recommended, and, in cold weather, clothing of the body. [H. L.]

Dialysis is the name of the process employed for the separation, when in solution, of crystalloid from colloid substances. Crystalloid bodies include all those compounds which, when in solution, readily pass through certain membranes, whilst colloidal bodies include those substances which either do not pass through at all or pass through with great slowness. The membranes used are either of parchment or parchment paper, or animal bladder. The membrane is tightly stretched and secured over a wooden hoop or some other conveniently shaped vessel; the apparatus thus formed is called a dialyser.

The solution for dialysis is placed inside the dialyser and the latter then floated in running water. In time the crystalloid substance in the solution in the dialyser will all have diffused into, and been carried away by the running water, leaving the colloid substances behind in the dialyser. It is essential to float the dialyser in running water so as to prevent the concentration of the crystalloid in the water in which the dialyser is floating to a strength equal to that of the solution which is being dialysed. [R. A. B.]

Diamond-back Moth. See PLUTELLA.

Dianthus, a large genus from which some of the most delightful of garden plants, such as Carnation, Pink, and Sweet William (which see), have been obtained. The species proper that are cultivated are *D. chinensis*, an annual, commonly known as the Indian Pink, and of which there are numerous varieties: *Hedwigii*, *laciniatus*, Crimson Belle, Eastern Queen, and others. The seeds are sown early in spring, and either transplanted or thinned as soon as they are large enough. They are quite easy to manage, and are most decorative when in flower from June onwards. The alpine species are hardy perennials, are most at home in the rock garden, where they revel in soil with which broken limestone has been freely mixed, and in a sunny position. The following are the best: *D. alpinus*, 4 in. high, flowers rose, spotted with crimson; *D. callizonus*, 2 in. high, flowers large and rich rose-red; *D. cæsius*, the Cheddar Pink, 6 in. high, flowers rose; *D. neglectus*, the Glacier Pink, 3 in. high, flowers 1 in. across, bright-rose; *D. petræus*, 6 in. high, flowers rose; *D. plumarius*, the Common Pink, is wild in Britain; *D. superbus*, the Fringed Pink, flowers rose coloured. These also grow well on old walls, often forming large cushions and living for many years when once established where the conditions are favourable. [W. W.]

Diarrhœa.—The frequent expulsion of fluid fæces is generally known as diarrhœa, and is to be distinguished from super-purgation and dysentery (which see). Diarrhœa is commonly the expression of an irritable condition of the lining membrane of the alimentary canal, and may be caused by improper food, excess, sudden changes, imperfect mastication, bad water, chills, exhaustion, and exposure to extremes of climate. So many causes are there for diarrhœa, that the animal owner is invited to consider them with a view to removal of the cause rather than to seek for a panacea, or resort to drugs in the first instance. The irritation of intestinal parasites may be the cause, or failure of the liver or other organs to produce normal secretions, when it will be obvious that our measures must be directed to the expulsion of the enemy, or the restoration of function in the organ that is acting imperfectly. One of the uses of bile in the intestine is that of an antiseptic, and if the quantity poured into the canal is insufficient or de-

fective, fermentation of the ingesta follows, irritation of the membrane is set up, and diarrhœa is caused. The association or interdependence of the lining and the covering (mucous membrane and common integument) must always be borne in mind, and the disposition to act vicariously. A chilling wind on the freshly clipped surface of a horse may result in diarrhœa. The irritation of worms in the canal may result in hidebound and harshness of the coat.

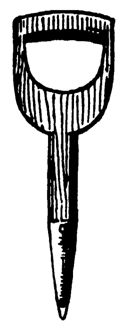
The frequency of diarrhœa or scour in young animals is due to indigestion, as when weaned calves or hand-reared foals and lambs are fed at intervals too long, and with too much at a time, or perhaps unsuitable substitutes supplied for the maternal fluid. Diarrhœa may then be regarded as a curative effort on the part of nature to unload the canal; and this was recognized by the earliest practitioners of veterinary medicine, who prescribed an aperient when an astringent would seem to be indicated. It will be found in the diarrhœa of sucking animals that an aperient of castor oil, suited to the age and species, is a safe and usually wise procedure, whether or not this is followed by other remedies. The latter usually consist in the administration of astringent medicines, of which bismuth, chalk, catechu, opium, acacia gum, and oak bark are among those most favoured by veterinary practitioners. See MEDICINES, DOSES OF. [H. L.]

Diaspis rosæ (the Rose Scale, or Scurvy Rose Bug) is a scale insect which infests wild roses, and occasionally does much harm to the cultivated plant, especially in the south-west of England. The female scale is white, round, and rather flat. The male scale is small and elongated. Eggs are laid in August, and the larvæ, which are orange-coloured, soon overrun the plant, which seems to be powdered with red dust. At this time, spraying with soft soap and quassia is useful. Infested standards and climbers should have the bark scrubbed with paraffin emulsion in February. Brier stocks for budding should be examined for this pest. [C. W.]

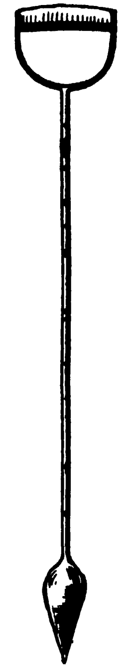
Diastase is the name of an enzyme under the influence of which starch is converted into sugar. It occurs widely distributed throughout the vegetable kingdom and in some animal organs. It is found most abundantly in germinating seeds, more particularly that of barley. Diastase is most conveniently prepared by shaking up green malt in water. On adding absolute alcohol to the watery extract, the diastase precipitates out. After purification, the diastase obtained is a white amorphous powder, soluble in water. The sugar maltose is the substance finally obtained by the action of diastase on starch. [R. A. B.]

Diatomaceous Earth.—This material is also well known by the German trade name of *Kieselguhr*. It is a porous grey earth, drying practically white, and distinguished from the equally friable 'shell-marls' by not effervescing or dissolving in acids. It consists of the minute siliceous cases or frustules of unicellular plants (diatoms), which flourish in lakes and also in the sea. These frustules, of very varied form, are easily recognized under the microscope. Diatomaceous earth, perhaps underlying grassland, may have a considerable commercial value. It is used as a polishing material, as a groundwork in dynamite and disinfecting powder, for making non-conducting bricks, and for other purposes, and may be dug out with a spade like peat. Examples are the broad deposits near the outlet of the Bann from Lough Neagh, and those worked in the Isle of Skye. [G. A. J. C.]

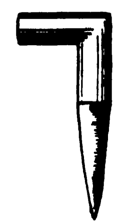
Dibble, Dibbling, and Dibbling Machines.—Dibbling is confined now mainly to the transplanting of plants, such as cabbages,



Steel-shod Dibble



Long Iron Dibble (operator uses one in each hand when corn-dibbling).



Steel-shod Dibble

kohlrabi, and young turnip plants, to produce seed. It is little practised for corn seeding, but is used for beans, which are still dibbled in some districts; wheat, barley, and oats are rarely planted with the dibble except on very small plots, though as recently as thirty or forty years ago it was extensively done. There is no method of planting or seeding corn so accurate, or which produces a better plant or braird; moreover, the quantity of seed required is far less than under any other process; as little as one peck per acre of wheat will give a good braird on land in a high condition, though it is risky, because birds and insects may thin the crop below the possibility of a profitable return. Corn drills are more expeditious, and deposit the seed with sufficient accuracy as to quantity and depth, and with less expense. Dibbling beans is in favour in some districts on heavy land, espe-

cially for spring beans, as it is possible to dibble earlier than is desirable for horses to be allowed on the land; moreover, the beans are better for being planted early. The dibble is a very simple tool, and no better is made than one consisting of a spade handle with a few inches of the tail pointed and shod with steel. The whole length of a dibble should not exceed about 10 in.; if longer, they are not nearly so convenient to work. A good dibble can also be made from a stout piece of wood with a right-angle turn. For 'double' dibbling corn, a pair of longer dibbles are sometimes used; these are about 2 ft. 6 in. in length, and the operator walks backward, striking a vertical hole, and with a quick twist of the wrist when withdrawing leaves a clean bore. In corn seeding it is usual to employ a boy to drop the grain, but in bean dibbling with a single dibble it is not unusual for the man to drop the seed and fill in earth over it with a flick of the dibble.

Dibbling cabbages, kohlrabi, and other of the root crops possessing hard fibrous roots is not nearly as much practised as it might profitably be. Men unaccustomed to the work are slow, and the work is not then popular with either master or men, though when they acquire the knack they have no objection to it, and at a cost of 8*s.* to 10*s.* an acre it is not expensive. A capable man can plant 5000 plants in a day, and in the turnip seed-growing districts a skilled man plants an acre with 40,000 to 60,000 plants in a week, from scattered plants, not plants laid just on the spot. In working a gang of seven, one man drops or scatters the plants for the other six, and thus each gets a rest from dibbling alternately. The first dibbler uses such plants as he finds most convenient, and flicks the surplus ones on to the row of the man next to him, and so on. Experienced planters work round a plot of land in the same way as part of a land is 'cast', so that they do not return on the row next to the one they have just completed in coming up the field, but cross to one where they will be working with their right hand next to work completed when going down the field. A left-hand man is at considerable disadvantage, as he has to cross his planting hand to pick up his plants, and this is a hindrance which will be equal to some poles of planting in a day. Many planters carry the plants in their left hand, but it is not quite so expeditious as the scattered method when done by skilled men, except when planting at wide distances. The planter should always place his heel about the roots of a plant; this, with a little experience, he does almost unconsciously and without hindrance. A dibble is sometimes used for planting potatoes, and makes good work; it is, however, slow to use, and has little advantage over the spade. It is stoutly made, and is provided with a 'tread' to force it into the ground.

Mechanical dibblers have been employed, and at one time the Royal Agricultural Society offered great inducements to engineers to produce efficient dibblers; but they possess deficiencies, and nothing has superseded the hand dibble in capable hands, and the corn drill has rendered the corn dibble unnecessary. [W. J. M.]

Dickson, Adam (1721–76), minister of Duns, in Berwickshire, a scholar of some repute, and a noted writer on agricultural subjects. His chief work is a Treatise on Agriculture, which treats of soil, tillage, manuring generally, and various systems of farming. This treatise for many years was a standard work of reference; it was eminently practical, and well adapted to farming in Scotland. In another work, Essay on Manuring, the principles laid down are quite in accordance with modern practice, and the views expressed therein were directed against the writings of Tull, who held that careful cultivation of the soil was all that was necessary for the growth of crops. He died before his last work, Husbandry of the Ancients, was completed. [R. H. L.]

Dicranura vinula (the Puss Moth) is a large grey, downy moth which lays its eggs on trees of the poplar and willow tribe. Its well-known caterpillar is remarkable for its two long tail filaments, which emit rose-coloured streamers, and for the 'terrifying' attitude it adopts when disturbed. It sometimes does considerable harm in nurseries, but its large size renders hand-picking practicable. Cocoons may be destroyed in winter in crevices of the bark of infested trees. [C. W.]

Dictamnus.—The Burning Bush (*D. fraxinella*) is a pretty herbaceous perennial with pinnate leaves on stems 2 to 3 ft. high, each terminated by an erect raceme of purple or white flowers, which are at their best in June. The whole plant is aromatic, owing to the secretion of an inflammable oil, which is most abundant on the flower-stalks, and if a match be applied it flames like gunpowder. The plant is quite hardy, and very decorative. [W. W.]

Digestion. — Strictly speaking, digestion begins in the mouth, where the food is masticated and soaked with the saliva, a fluid secreted by the salivary glands.

The lips in the horse, pig, and sheep play a prominent part in the prehension of the food; the lips bring the food into the mouth, and then by the action of the tongue it is handed to the molar teeth for grinding. If a horse is grazing, the grass is nipped off with the incisor teeth. The sucking animal by means of its lips forms a vacuum, which causes the milk from the dam to flow readily into the mouth.

The ox uses its tongue to bring the food into the mouth, nipping the grass, &c., with its incisor teeth and dental pad simultaneously. A peculiarity in connection with the incisor teeth of the ox, sheep, and goat is that they are movable in their sockets, there being a dental pad, representing the upper incisors, which facilitates the protrusion of the tongue. This act would be interfered with if incisor teeth were present in the upper jaw.

Horses thoroughly masticate their food with the molar teeth before swallowing it, but in cattle and sheep the food is only slightly masticated to begin with, then swallowed, but subsequently returned to the mouth for its thorough

mastication. It has been calculated that it takes about eight minutes for a horse to eat a lb. of corn and about fifteen minutes to consume a lb. of hay.

It is astonishing what a large quantity of saliva is secreted per day, estimated by Colin as being in the horse 84 lb., and in the ox 112 lb., influenced, of course, by the nature of the food. Hay, for instance, induces a very copious flow of saliva, and so do oats, barley, &c. The chief salts contained in the saliva are the phosphates of lime and magnesia, calcium carbonate, and chlorides of the alkalis.

The saliva enables the animal to swallow its food with greater ease, and the majority of physiologists believe that it does exert chemical action on starch, though one authority has expressed a contrary opinion. Meade Smith, in his Physiology of the Domestic Animals, says that the saliva of the horse will convert crushed raw starch into sugar in fifteen minutes, and that the process will continue in the stomach. The salivary secretion is under the control of the nervous system, and the organic matter contained in the saliva is formed by the cells entering into the structure of the salivary glands.

In the horse and dog the stomach is comparatively simple, but in the ox, sheep, and goat it is divisible into four compartments, known as the first, second, third, and fourth compartments, into each of which the food passes in its turn; but the fourth compartment is the true digestive stomach. In the calf the latter compartment is the largest division. It is impossible to study the digestive processes of the horse, &c., without having a knowledge of the structure of the animal's stomach. The average capacity of the horse's stomach is from 3 to 4 gal. About one half of its lining is merely a continuation of the same membrane as that lining the gullet, and it is known as the cuticular, and it does not play any active part in the digestive process. This, of course, is the end nearest to the gullet—cardiac portion.

The other portion of the stomach is lined by a membrane that does secrete juices, and it is called the *villous coat*. It begins at the so-called *boundary* line, that is the junction of the cuticular and villous coats, the last named extending to the pylorus, or junction of stomach with small intestine.

Although the villous lining occupies this half of the stomach, it is only one portion—the *fundus*—of the lining that secretes the gastric juice proper, viz. pepsin and acid, whereas pepsin only is secreted in the pyloric portion of the stomach There are two varieties of secreting glands in the villous coat, and each gland has a body or secreting portion, and an outlet or duct, the latter opening on the surface of the coat. Mucous glands are numerous in the deeper layers of the villous coat, and secrete mucin, which forms the albuminous material so easily seen when the stomach lining is washed with water.

The gastric juice is acid, and contains two ferments, *pepsin* and *rennin*, the former splitting up the proteid substances of the food, and the latter acting as a milk-curdling ferment, being specially abundant in the stomach of the calf. Gastric juice converts albumins into *peptones*. According to Ellenberger and Hofmeister, the digestive changes in the stomach of the horse are divisible into four stages as follows:—

First Period.—This is a short one, and the starch is converted into sugar, accompanied by lactic fermentation.

Second Period.—The starch is chiefly converted into sugar in the left sac, and a small quantity of proteid is converted into peptone in the fundus; the acids present are lactic in the left, and a little hydrochloric in the right sac.

Third Period.—In this period both starch and proteid conversion takes place.

Fourth Period.—This is a pure proteid digestion, there being no starch conversion owing to the presence of hydrochloric acid throughout the digestive lining.

These observers fix the following periods concerning digestion:—

After a moderate feed, digestion is at its height in 3 or 4 hours.

After a full feed, digestion is at its height in 6 to 8 hours.

After an immoderate feed, digestion is delayed still longer.

These same physiologists declare that the conversion of starch in the stomach is not only due to the saliva swallowed, but also to the development of ferments from the food.

In support of this statement these observers found that oats yielded a starch-converting ferment, active at the temperature of the body, but destroyed by boiling; hence one of the reasons why boiled foods don't do for horses.

The starch in the stomach is converted into soluble starch, then dextrin, and afterwards sugar.

Milk is curdled in the stomach; fats are not acted upon, but cellulose is said to be so by a cellulose-dissolving enzyme.

Water hinders digestion and causes a wastage of nutritive pabulum. Foods pass out of the stomach into the bowel according to the order in which they have been fed to the horse, so that if hay be given it is a wise plan to give it an hour or so before the corn, in order that the most nutritive food may have the full benefit of stomach digestion.

In swine the stomach digestion of food varies in the different regions of the stomach, the organ in these animals being half herbivorous and half carnivorous. In the dog, the gastric juice is rich in hydrochloric acid, and digestion slow.

The total capacity of the ox stomach is said to be 60 gal.. In the *rumen* or *first compartment* the gastric fluid is alkaline, and here the herbage undergoes a churning process. This compartment holds the food for rumination, and it is said never to be empty.

In the *second compartment* or *reticulum* (honeycomb) the contents are fluid and alkaline, whilst the very opposite is the case with the contents of the *third compartment* or *omasum*, where the food is always in a dry state, the juices having been extracted by being

squeezed between the leaflike folds of its lining membrane, and papillæ thereon. The extracted juices pass on to the *fourth compartment* or *abomasum*, where the gastric juice is secreted, and proteids converted into peptones—true digestion.

According to Ellenberger, the carbohydrates of the food are digested by enzymes contained in the food, therefore, in all probability, digestion does occur in the rumen or paunch, to some extent.

Although *conversion* of food occurs in the stomach of the horse, Colin's experiments with strychnine go to prove that *no absorption occurs* in this organ. This was shown to be the case by tying the outlet with a ligature and then introducing strychnire, which produced no results so long as the outlet was kept tied, but directly this was removed, strychnine poisoning followed. The same experimentalist showed that there is practically no absorption from the true digestive stomach of ruminants, *i.e.* from the abomasum.

The chyme from the stomach is poured into the duodenum, or beginning of the small bowel, and here it is brought into contact with the digestive fluids, which are the bile, the pancreatic juice, and the intestinal juice.

The bile is an alkaline fluid with a bitter taste, and either dark-green (herbivora) or brownish in colour. The latter is due to the presence of the pigments *bilirubin* (carnivora) or *biliverdin* (herbivora), although both may be present in a single sample of bile. Two salts and two acids are present in bile, and the secretion of bile is a continuous one by the liver cells, and in those animals having a gall bladder (absent in the horse) it is stored up in that receptacle, for future use.

The bile acts in consort with the pancreatic juice, especially on fats, and also as nature's laxative. About 9 oz. of bile are secreted per hour in the horse, and 4 oz. in the ox, but only about 3 drm. in the dog per hour.

The liver not only secretes the bile, but manufactures and acts as a storehouse for glycogen or animal starch, having the formula $C_6H_{10}O_5$, derived from the sugar in the food, and when required for use, it is again *reconverted* into sugar.

The pancreatic juice is a watery alkaline fluid containing three ferments, viz. trypsin, amylopsin, and steapsin. The first named converts the proteids into peptones, the second one starch into sugar, whilst the steapsin splits fats into fatty acids and glycerine.

The intestinal juice (*Succus entericus*) is manufactured by Brunner's glands, and by the glands of Lieberkühn, the latter being tubular glands. This juice is said to convert proteids into peptones, starch into sugar, and cane sugar into grape sugar.

The chyle in the small gut is a yellowish fluid, and flows into the cæcum in about six hours, according to Ellenberger.

The large intestines necessarily play a most important part in the digestive process, more especially in horses, and the '*only juice poured directly into them* is the intestinal juice.

The large bowels comprise the cæcum or blind gut; the double colon and the single colon, which ends in the rectum or straight gut.

In the horse, the cæcum is large and its contents fluid, with an alkaline reaction.

Its chief functions appear to be as a storehouse for water, and for the digestion of cellulose. Its inlet and outlet are close together, and the latter leads into the double colon, which has enormous capacity, and its contents greenish in colour, quite unlike the contents of the single or floating colon, which succeeds it; whilst in the rectum the residue is converted into the fæces as rounded masses in the horse, and then expelled; but in the ox the fæces are pultaceous, solid in the sheep and goat, solid in the dog, though less solid in swine.

The nervous mechanism of the bowels is adjusted by the vagus and sympathetic. Exercise has a most important influence over the peristaltic movements of the intestines, hence the advisability of allowing this in torpid conditions of the bowel. [F. T. B.]

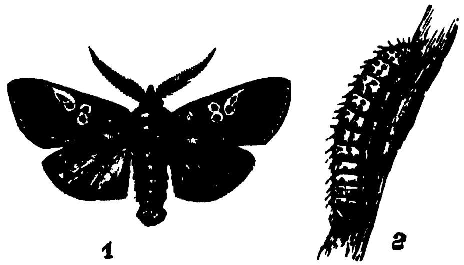
Digging.—The cultivation of soil means the breaking up of the surface so as to allow the air and water to do their work, and also to render it suitable for sowing and planting operations. The gardener digs when the farmer ploughs and harrows, and the increase in the yield of properly dug soil compared with that treated by agricultural methods is often very marked indeed. Trenching, which means breaking up and turning over the soil two spits deep (about 2 ft.), possesses corresponding advantages over simple digging. The ability to use a spade really well comes only after considerable practice, whilst the time to dig and the treatment of the soil during the operation so as to get the best results requires some horticultural training. Generally, it is best to dig land in the autumn, preferably when it is on the dry side, leaving the soil in clods to benefit by exposure to frost and air. Much labour is saved by using a broad-tined or digging fork instead of a spade for heavy land. [W. W.]

Digitalis.—The Common Foxglove (*D. purpurea*), a biennial herb of the order Scrophulariaceæ, is certainly one of the finest of our native flowers; and although several other species of Digitalis, a genus confined to the western temperate portion of the Old World, are handsome plants, this one, of which there are now improved forms, is sufficient for most gardeners to concern themselves with. It is particularly suitable for growing in a thin shrubbery, and in woodlands where it is not abundant in a wild state we heartily commend the scattering of its seeds. The yellow-flowered *D. grandiflora* is the best of the perennial species. An exceedingly powerful drug is prepared from the leaves of *D. purpurea*. It is principally employed in cases of heart disease. [W. W.]

Dill (Anethum). — The Common Dill (*Anethum graveolens*) is an annual umbelliferous plant with yellow flowers, readily mistaken for its ally Fennel. It is cultivated for its 'seeds', which when distilled with water yield a volatile oil which is the active ingredient in dill water, used to relieve pains and gripes in the bowels.

Crops of dill seeds are raised in France, Spain, and Egypt along the Mediterranean, but with us all attempts at cultivation have proved unsuccessful. [A. N. M'A.]

Diloba cæruleocephala (the Figure-of-8 Moth) is a frequent pest in orchards. It is about $1\frac{1}{4}$ in. across the extended wings, and its brown fore wings are marked with the figure 8 in white. Its larva is the 'blue-head' caterpillar, green in colour, but striped with yellow and spotted with black, and attaining 2 in. in length. The chrysalis is hidden in crannies in the bark, or in the shelter afforded by neighbouring walls. The caterpillars only hold loosely on to the trees, and are readily shaken down and destroyed. The chrysalids may be killed by an alkali wash applied to the tree trunks in winter. [C. W.]



1, Figure-of-8 Moth (*Diloba cæruleocephala*). 2, 'Blue-head' Caterpillar

Dilophus febrilis (the Fever-fly). See FEVER-FLY and BIBIONIDÆ.

Diluvium, a term practically equivalent to the English 'drift' (see art. DRIFT). The widely spread deposits, containing boulders carried from some distance, which are now recognized as due to the former presence of glaciers, were at one time held to be laid down by sudden floods. The 'diluvium' of continental writers thus typically underlies the modern river-alluvium, and much of the material of the latter is derived from it. [G. A. J. C.]

Dimorphism, the term used when there are two different forms of the same kind of animal. The most familar cases are those in which the males and females are markedly different in appearance, *e.g.* peacock and peahen, lion and lioness. This is called sexual dimorphism. Less familiar are cases where the dimorphism has not *obviously* to do with sex. Thus in some of the Hercules beetles (e.g. *Xylotrupes gideon*) the males occur in two forms, one with enormous horns, and the other (like the females) with little or no development of horns. The butterfly *Papilio glaucus* has two types of females, one yellow and the other black. Our common cowslips and primroses occur in two forms in about equal proportions, some having 'pin-eyed' or long-styled flowers, and the others having 'thrum-eyed' or short-styled flowers. There is also dimorphism in the crimson flax (*Linum grandiflorum*), while in the case of *Lythrum salicaria* there is trimorphism. Similarly, one might say that there is trimorphism in the beehive, for the drones, the queens, and the workers differ in many details. In some ants there are several different types of workers, so that we have to do with polymorphism. The subject is one of great difficulty, and experiments as to the inheritance of the distinctive features in dimorphic forms are much needed. They have been begun in regard to primulas by Bateson and Gregory. It may be that some of the cases of dimorphism in one sex are secondary results of peculiarities in the reproductive system; it may be that some cases of dimorphism are *modificational*, *i.e.* are due to differences in nutrition and environment, or even to the presence of parasites; it seems probable that other cases depend on slight variations in the germinal material at very early stages, *e.g.* snails with right-handed or left-handed spiral shells. See Darwin, Descent of Man; Bateson, Materials for the Study of Variation (1894), p. 38; T. H. Morgan, Experimental Zoology (1907), p. 160. [J. A. T.]

Dingo (*Canis dingo*).—The Australian 'Wild Dog' is about the size of a large sheepdog, and has long muscular legs, a bushy tail, and an elongated head, with short, almost erect ears. The head is held high in running, and the tail is carried horizontally. The colouring is a mingled tan and grey, the grey hairs being coarse and woolly, the tan soft and silky. Black individuals sometimes occur. In habit the dingo is foxlike, usually lying concealed throughout the day and making predatory expeditions at night. They sometimes hunt in packs of four or five, probably family parties. The dingo was the only mammal, except the marsupials, which was found in Australia when it was first visited by Europeans in the 17th century. It used to be exceedingly abundant, partly wild, partly living in a half domesticated relation with the natives. The origin of the dingo is puzzling, but it is generally regarded as having been introduced by earlier settlers, and not as a native animal. Its bones have been found in Pleistocene deposits, but this is not inconsistent with its introduction by man in ancient days. This view is also suggested by its resemblance to a race of dogs that used to occur in the Salomon Islands, Japan, and the hill country of Java.

While dingoes were abundant they wrought terrible havoc among flocks—one run alone is said to have lost more than 1200 sheep and lambs within three months—and the settlers used every possible means, shooting, trapping, poisoning, &c., to exterminate them. They are now relatively scarce.

The dingo breeds in captivity, and its behaviour towards its young is like that of other dogs. It can be tamed if taken young, but its temper is uncertain, and it is said never to lose its hostility to the domestic dog. It is also said to feign death with great persistence. But too many things are said about the dingo. [J. A. T.]

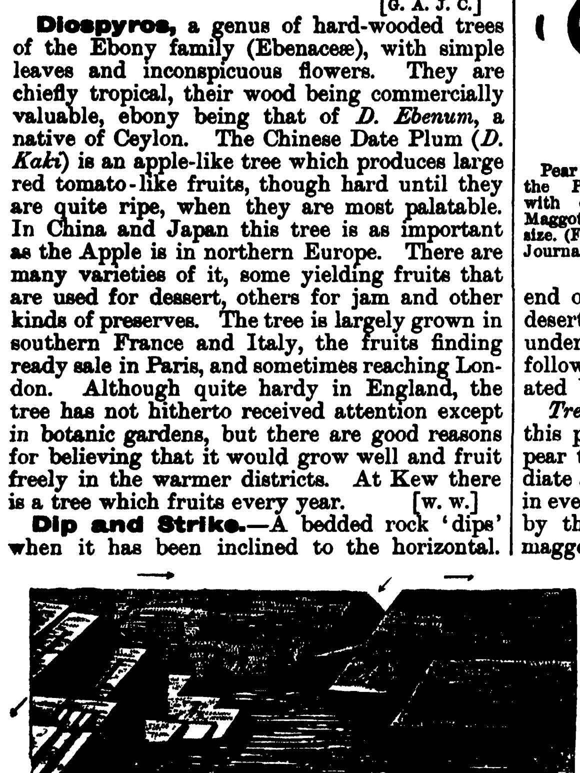
Dinmont, a shearling tup or wether—from first to second clip.

Diorite.—Haüy used this term in 1819 for rocks composed of hornblende and felspar, in which the hornblende was in excess. It is now restricted to types with a lime-soda or lime-felspar. *Augite-diorites* are usually called gabbros

(see art. GABBRO). The 'greenstones' of older authors are mostly diorites. Soils due to the decomposition of diorite are liable to be stony, and the rock may stand up in dark-coloured bosses in the fields; but lime and phosphoric acid are adequately present, and in some areas of old crystalline rocks, such as much of the Dalradian Highlands, patches of diorite may be the only sufficient source of these materials. Both the felspar and the hornblende, and also the pyroxene so frequently associated with them, may yield up their lime in the form of a carbonate, and veins and crystals of calcite occasionally appear in the hollows of the rock. Hence diorite soils have a high reputation, though the resistance of the rock to denudation often causes it to produce a rugged country. [G. A. J. C.]

Diospyros, a genus of hard-wooded trees of the Ebony family (Ebenaceæ), with simple leaves and inconspicuous flowers. They are chiefly tropical, their wood being commercially valuable, ebony being that of *D. Ebenum*, a native of Ceylon. The Chinese Date Plum (*D. Kaki*) is an apple-like tree which produces large red tomato-like fruits, though hard until they are quite ripe, when they are most palatable. In China and Japan this tree is as important as the Apple is in northern Europe. There are many varieties of it, some yielding fruits that are used for dessert, others for jam and other kinds of preserves. The tree is largely grown in southern France and Italy, the fruits finding ready sale in Paris, and sometimes reaching London. Although quite hardy in England, the tree has not hitherto received attention except in botanic gardens, but there are good reasons for believing that it would grow well and fruit freely in the warmer districts. At Kew there is a tree which fruits every year. [W. W.]

Dip and Strike.—A bedded rock 'dips' when it has been inclined to the horizontal.



Dip and Strike

The horizontal arrows indicate the Strike; those pointing towards the left-hand corner show the direction of the Dip.

The amount of dip is the steepest possible angle that can be made with the horizontal by a line drawn in the plane surface of the bed. This line, when projected on a map, runs in a particular compass-direction, known as the direction of dip. The sign $\longrightarrow 30$ on a geological map thus means that the beds dip down eastward at 30° below the surface. Such signs have no reference whatever to the slope of the surface itself.

Strike is the direction of a horizontal line drawn in the plane surface of a dipping bed. It thus expresses how the upturned edges of strata run or strike across the country. Dip may vary in amount, and may even be reversed in direction, while strike remains the same. From the annexed figure it will be clear that the line of dip and the strike are perpendicular to one another. Dip has naturally a great influence on the amount of country over which a given set of rocks extends at the surface, and also on questions of water supply. [G. A. J. C.]

Diplosis, a genus of midges or small gnat-like flies (Diptera). See next art.

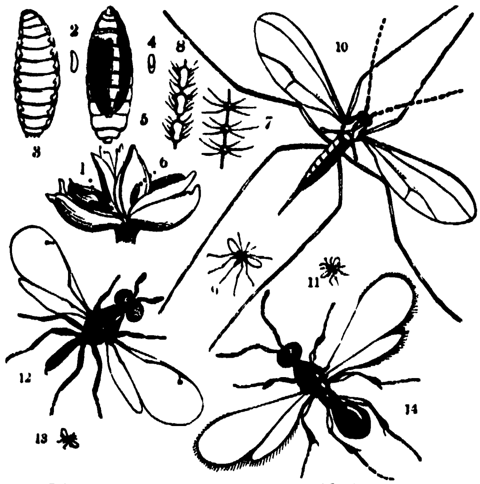
Diplosis pirivora (the Pear Midge), first observed in England in 1893, has recently become a very serious and widespread orchard pest. The small black midge lays its eggs in the unopened pear blossoms in April. The fruit is not prevented from setting, but the maggots eat into the core of the young fruit, which is stunted and distorted. They are white grubs, tapering at either end, and closely resembling cheese maggots in appearance, and in their power of jumping by applying head and tail together and separating them with a spring. They are fully grown at the end of May, and either then or in June they desert their quarters and seek the ground, under the surface of which they hide till the following spring. Their departure is accelerated by rain.

Pear infested by the Pear Midge, with one of the Maggots natural size. (From R. A. S. E. Journal.)

Treatment. — Fruit growers unfamiliar with this pest are strongly advised to inspect their pear trees carefully in May, and to take immediate action if the disease is found to be present in ever so small a degree. It is easily recognized by the stunted fruit, and the small jumping maggots they contain. If confined to one or two trees, it is well worth while to strip off the whole of the fruit and burn it; but to be effectual this must of course be done before any of the maggots have left the pears and entered the ground. If the attack is observed too late for this measure, it is well to know that a heavy dressing of kainit beneath the trees has been found to destroy the puparia, and to prevent the emergence of the midge during the following season. [C. W.]

Diplosis tritici (the British Wheat Midge) causes great loss to the wheat crops in some seasons. The eggs are laid in the ear, and the little lemon-coloured larvæ (fig. 1) abstract the juices, and cause the grain to shrivel; when full grown (fig. 2, magnified at 3) they either enter the earth to become pupæ, or remain through the winter in their pellucid skins (fig. 4, magnified at 5, attached to the grain 6), and do not produce flies until the following June. The wheat midges are pale-ochreous or orange; downy; eyes large and intensely black; the horns are brown, hairy, and very long in the male, being composed of twenty-five globose joints,

which are strung like beads (fig. 7). In the female they are only thirteen-jointed, the joints elliptical and contracted at the middle (fig. 8); the body tapers towards the apex, with



Diplosis tritici (British Wheat Midge), figs. 1-10. *Platygaster tipulæ*, figs. 11, 14. *Macroglenes penetrans*, figs. 12, 13.

a fine oviduct, which can be extended twice the length of the abdomen (fig. 9, magnified at 10). The male is smaller than the female, with a short slender body. Nothing can be done during attacks, but afterwards it is most important to destroy the chaff, which is sure to contain myriads of puparia.

Platygaster tipulæ and *Macroglenes penetrans* are parasitic insects infesting the Cecidomyiæ, a group of insects some of which (as the Hessian Fly) are very destructive to crops. [J. C.] [C. W.]

Dipping Sheep. See SHEEP, DIPPING OF.

Dips. See SHEEP DIPS.

Dipsacus (the Teazle family).—A small genus of prickly biennial plants, natives of Europe and Northern Asia, *D. sylvestris*, the Common Teazle, being wild in England, and often growing 6 ft. high, with long lance-shaped prickly leaves, united at their bases and forming a cup round the stem, the flowers being borne in a cylindrical stem formed of stiff prickly bracts and scales, each terminated by a long needle-like point. The Fuller's Teazle, *D. Fullonum*, is very similar to the above, the chief difference being in the flower-head, the scales on which have hooked instead of straight points. These heads are used in the manufacture of woollen cloth, being fixed in frames over which the fabric is passed, and the soft hooks, by raising to the surface the wool fibres, impart to it what is known as 'nap'. Every piece of fine broadcloth requires up to 2000 Teazle heads to bring out the proper nap, fresh heads being needed for each piece. The plant is largely grown in Yorkshire and on the Continent to meet the demand for these heads. *D. laciniatus* is cultivated in gardens, its attraction being in its large deeply cut foliage. [W. W.]

Disbudding.—For the production of certain qualities in fruit, leaves, or flowers, cultivators have sometimes to resort to practices which are really more or less mutilation. One of these is the operation known as disbudding, that is the removal of a number of buds so as to divert growth into those that remain. It is largely practised with fruit, and by growers of exhibition flowers such as roses, chrysanthemums, dahlias, &c., and it is surprising how great a difference this operation sometimes makes in the size and quality of the produce. Essentially it does not differ from pruning as practised on fruit trees, thinning as practised on grapes and peaches, or pinching as practised on chrysanthemums. [W. W.]

Diseases of Animals Acts.—The object of the legislation under this head is to prevent the spread of contagious disease among animals, and to provide for its suppression. Commencing in 1869, various Acts have from time to time been passed, which are now consolidated by the Diseases of Animals Act, 1894, as amended by the Acts of 1896 and 1903, and the various Orders passed by the Board of Agriculture and Fisheries. The method adopted to attain the end in view is, that in the case of home animals infected they should be isolated and in certain cases slaughtered, while as regards foreign animals—if permitted to be landed at all—they should be slaughtered at the port of landing.

The execution of the Acts is entrusted to central and local authorities. The central authority is for England, Wales, and Scotland the Board of Agriculture and Fisheries (hereinafter referred to as 'the Board'), and for Ireland the Department of Agriculture and Technical Instruction. The local authorities in England, Wales, and Scotland are the town councils in boroughs having not less than 10,000 inhabitants in England and Wales, or 7000 inhabitants in Scotland, and in counties and smaller boroughs the county councils. In Ireland the local authorities are the councils of each county or county borough.

The Board has power from time to time to make such Orders as they think fit, for the prevention and checking of disease. They may also by order authorize a local authority to make regulations for any of the purposes of the Act, or of any Order of the Board, subject to such conditions, if any, as the Board think fit to prescribe. In virtue of the powers conferred on them, the Board has issued a number of Orders, copies of which, or of any Order that may be made in future by the Board in substitution or in supplement of these Orders, may be obtained free of charge on application to The Secretary, Board of Agriculture and Fisheries, 4 Whitehall Place, London, S.W.

These Orders are of a temporary character, and are liable to be recalled at any time, though many of them have stood for some years. They are not gone into in detail here, but they will be referred to under the various headings to which they refer. Generally speaking, the important point for the owner of stock diseased or suspected of disease is, that he must with all

practicable speed give notice of the fact to a constable of the police force for the police area wherein the animal so affected or suspected was. Thereafter the Board or the local authority must act, and they will publish, by placards, handbills, or otherwise, the regulations which they are empowered by the Act to make as to isolation, movement, &c., of the animals, fodder, litter, dung, or other things.

POWERS AND DUTIES OF LOCAL AUTHORITIES.—Local authorities must execute and enforce the Act and every Order of the Board so far as enforceable by them. They must keep a record of all animals slaughtered by their order. They are empowered to provide wharves, stations, lairs, &c., for the landing, sale, slaughter, or disposal of foreign or other animals, fodder, litter, dung, or other things, for which purposes they are empowered to acquire land, and may charge for the use of such wharves or other places such sums as may be imposed by by-laws, which tolls are, however, subject to revisal by the Board. Every local authority must appoint as many inspectors and other officers as they think necessary for enforcing the Act, and must appoint at least one veterinary inspector. If on enquiry the Board is satisfied that the inspector of a local authority is incompetent, or has been guilty of misconduct or neglect, they may direct his removal. The local authority must make such reports to the Board as the Board may require. On their failure to execute any of the provisions of the Act or of any Order, the Board may by Order empower a person therein named to execute the provisions.

For the purposes of the Act, 'cattle' means bulls, cows, oxen, heifers, and calves; 'animals', except where otherwise expressed, means cattle, sheep, and goats, and all other ruminating animals, and swine; and 'disease' means cattle plague, contagious pleuropneumonia of cattle, foot-and-mouth disease, sheep pox, sheep scab, or swine fever (that is, the disease known as typhoid fever of swine, soldier purples, red disease, hog cholera, or swine plague). The Board has for certain purposes by subsequent Orders extended these definitions so as to include horses, asses, mules, and dogs under the definition of animals; and anthrax, glanders, epizootic lymphangitis, and rabies under the definition of disease.

The powers conferred on local authorities are, unless otherwise expressed, only exercisable within their district. It is, however, provided that the power to acquire land for wharves, burial of carcasses, &c., conferred on them by the Act, may be exercised by them with respect to land within or without their district. Moreover, one local authority may by agreement transfer its powers under the Act to an adjoining local authority, or they may agree to the formation of a united district.

ISOLATION AND NOTICE.—Every person having in his possession or under his charge an animal affected with disease, must (*a*) as far as practicable keep the animal separate from animals not so affected, and (*b*) with all practicable speed give notice to the police, who in turn must inform the local inspector, and in most cases must also notify the Board by telegram. The Board has power to make orders for prescribing and regulating the notice to be given.

INFECTED PLACES, AREAS, OR CIRCLES.—(1) *Cattle Plague.*—Where it appears to an inspector that cattle plague exists or has within ten days existed in a cowshed, field, or other place, he must sign a declaration thereof, and serve a notice on the occupier, whereupon the cowshed, field, &c., with all buildings contiguous thereto in his occupation, become an infected place. The inspector may further, if he consider it expedient, serve notices on the occupiers of all land or buildings within a radius of a mile, whereupon such lands or buildings become part of the infected place. Immediately thereafter the inspector must notify the Board of Agriculture, who shall enquire into the correctness of the declaration and may prescribe the limits of the infected place, or they may declare the place uninfected. The Board may at any time by order declare any place to be an infected place, alter the limits, or declare any such place to be free from plague. Further, the Board may at any time declare an area within which such an infected place exists to be an infected area, alter its limits, or declare the area to be free from plague.

(2) *Pleuropneumonia and Foot-and-Mouth Disease.*—Where an inspector believes that pleuropneumonia exists or has within fifty-six days existed, or that foot-and-mouth disease exists, or has within ten days existed, in any place, he shall serve notice thereof upon the occupier, and in the case of foot-and-mouth disease, if he thinks fit, also on the adjacent occupiers. Thereupon the place becomes an infected place, subject to enquiry by the local authority, who may prescribe limits or declare the place free from infection. The local authority must report their decision to the Board of Agriculture, and state whether they consider it expedient that an infected area should be declared, also whether it is expedient that any market or sale of animals within the area should be prohibited. When a local authority has declared a place to be infected with pleuropneumonia or foot-and-mouth disease, they may, on the advice of a veterinary inspector, declare the place to be free from disease on the expiry of fifty-six days from its cessation in the case of pleuropneumonia, and in the case of foot-and-mouth disease on the expiry of not less than fourteen nor more than twenty-eight days after its cessation. The Board may at any time declare a place to be infected with pleuropneumonia or foot-and-mouth disease, prescribe the limits, and declare it to be free from disease. They may further declare an area within which such infected place is situated to be an infected area, prescribe the limits of the area, and declare the area or part of it to be free from disease. They may prohibit or restrict the holding of any fair or market for the sale of animals within the area, and they may declare places or areas infected with other diseases than cattle plague, pleuropneumonia, or foot-and-mouth disease to be infected areas. Anyone owning or having charge of animals in an

infected place or area may, by notice, exclude strangers therefrom.

Movement of Animals.—In the case of pleuropneumonia, cattle, and in the case of foot-and-mouth disease, animals, must not, except in the cases and under the conditions prescribed by Order of the Board, be moved out of an infected place, and may only be moved into it if they are already affected. Cattle in an infected area but not in an infected place may only be moved into, out of, or within the area by licence of the local authority.

Slaughter.—All cattle affected with pleuropneumonia, and all animals affected with cattle plague or which have been in the same shed, stable, herd, or flock, or in contact with an animal affected with cattle plague, *must* be slaughtered. Cattle or animals suspected of these diseases or being in infected places may, if the Board think fit, be slaughtered. Animals affected with foot-and-mouth disease, swine affected with swine fever, or animals or swine suspected of these diseases respectively, or having been exposed to the infection, may be slaughtered by order of the Board. In the case of foot-and-mouth disease, the Board has by Order delegated this power of slaughter to the local authority.

In addition to the powers above referred to, the duty has been imposed by Order on local authorities of slaughtering (*a*) dogs affected or suspected of rabies, or which have been bitten by a diseased or suspected dog, (*b*) sheep affected with sheep pox, or (*c*) a horse, ass, or mule affected with glanders. In the latter case, if the owner of the animal objects to the slaughter it is not lawful for the local authority to cause it to be slaughtered except with the special authority of the Board.

Compensation.—Where animals—other than dogs affected with rabies—are slaughtered under the powers of the Act or subsequent Orders, compensation is provided on scales varying with the different diseases, and also according to whether the animal was or was not affected with disease at the time of slaughter. The provisions of the Act and Orders are as follows:—

(1) *Cattle Plague.*—(*a*) In the case of an affected animal, one half of its value immediately before it became affected, but not exceeding £20. (*b*) In every other case the value of the animal immediately before it was slaughtered, but not exceeding £40.

(2) *Pleuropneumonia.*—(*a*) In the case of an affected animal, three-fourths of its value immediately before it became affected, but not exceeding £30. (*b*) In every other case the value of the animal immediately before it was slaughtered, but not exceeding £40.

(3) *Foot-and-mouth Disease.*—(*a*) In the case of an affected animal, the value of the animal immediately before it became affected; and (*b*) in every other case the value of the animal immediately before it was slaughtered.

(4) *Swine Fever.*—(*a*) In the case of an affected animal, one half of its value immediately before it became so affected; and (*b*) in every other case the value of the animal immediately before it was slaughtered.

(5) *Sheep Pox.*—(*a*) In the case of an affected animal, one half of the value of the sheep immediately before it became affected, but not exceeding 40*s.* (*b*) In every other case the value of the sheep immediately before it was slaughtered, but not exceeding £4.

(6) *Glanders.*—(*a*) Where a post-mortem examination does not show the animal was affected, the full value of the animal immediately before it received the mallein test, but not exceeding £50 for a horse or £12 for an ass or mule; (*b*) where a post-mortem examination shows it was affected, one half of the value of the animal immediately before it received the mallein test, but not exceeding £25 for a horse or £6 for an ass or mule; and (*c*) where there is no post-mortem examination, such compensation as the local authority think expedient, being a minimum of £2 for a horse and 10*s.* for an ass or mule, and a maximum of one fourth of the value of the animal immediately before it became diseased.

If the method of ascertaining the compensation to be awarded is not expressly fixed by special Order, the mode of ascertaining it is laid down in the Animals (Transit and General) Amendment Order of 1904 and is as follows:—

Where the compensation offered to the owner of an animal which has been compulsorily slaughtered is disputed by him, the amount is settled by an arbiter, to be appointed mutually by the Board or Local Authority as the case may be and the owner, and failing agreement, by the Court. The arbiter must make his award within seven days of the date of his appointment. If the amount awarded is higher than that offered by the Board or the local authority, they must pay the costs of the valuation and all costs incurred by the owner in connection therewith. On the other hand, if the amount awarded is not more than the amount offered, the costs of the valuation and all costs incurred by the Board or local authority may be deducted from the compensation.

If the owner of an animal which has been compulsorily slaughtered has an insurance on the animal, the amount of compensation may be deducted by the insurers from the sum due under the policy. Compensation may be withheld if the owner or person in charge of the animal has been guilty of an offence against the Act.

The Board may reserve for observation and treatment any animal liable to be slaughtered, but subject to compensation as in the case of actual slaughter. The carcass of a slaughtered animal belongs to the Board or local authority, and may be buried, sold, or otherwise disposed of. If the sum received on the sale exceeds the compensation paid, the balance must be paid to the owner, under deduction of reasonable expenses. Ground in the occupation of the owner of the animal may be used for burying the carcass.

Foreign Animals.—The Board has power, whenever they deem it expedient for the purpose of preventing the introduction of disease, to make Orders for prohibiting the landing of animals or of any specified kind thereof, or of

carcasses, fodder, litter, dung, or other thing brought from any specified country into the United Kingdom or any specified part of such country, and they are to prohibit the landing of such animals whenever they are not satisfied that looking to the sanitary conditions of the animals in the foreign country, the circumstances are such as to afford reasonable security against the introduction of animals affected with foot-and-mouth disease. They have exercised this power to the extent of prohibiting the importation of animals from a large number of foreign countries. The Board may, however, make Orders admitting animals intended for exhibition or for other exceptional purposes to be landed. The rules with regard to foreign animals—except such as are prohibited to be landed, or are intended for exhibition or other exceptional purposes and the landing of which is allowed for the time being by the Board—are contained in the Third Schedule to the Act, which is as follows:—

Slaughter at Port of Landing.—(1) The animals shall be landed only at a part of a port defined for that purpose by order of the Board of Agriculture, to be called a foreign animals wharf.

(2) The animals shall be landed in such manner, at such times, and subject to such supervision and control as the Commissioners of Customs direct.

(3) The animals shall not be moved alive out of the wharf.

Quarantine.—The Board has power to make such Orders as they think fit, for allowing the landing of any foreign animals intended for exhibition or for other exceptional purposes without being subject to the provisions as to slaughter, but they are subject to the regulations as to quarantine contained in the Third Schedule to the Act, which are as follows:—

(1) The animals shall be landed only at a part of a port defined for that purpose by order of the Board of Agriculture, to be called a foreign animals quarantine station.

(2) The animals shall be landed in such manner, at such times, and subject to such supervision and control as the Commissioners of Customs direct, and subject to such conditions in respect of the animals, or of the vessel from which they are landed, as the Board by order prescribe.

(3) When landed the animals shall be placed in sheds or other receptacles in the quarantine station, prepared by the local authority, or the owners of the quarantine station, or the consignees of animals, or other persons, and approved by the Board.

(4) The animals shall not be moved out of the quarantine station except on conditions prescribed by order of the Board.

(5) Notwithstanding anything in the foregoing provisions of this part of this Schedule, the provisions of this Act relating to slaughter in case of the existence of disease, and to compensation or other payment in respect of animals so slaughtered, and to the ownership of carcasses of such animals, shall apply to animals within a foreign animals quarantine station.

No horse, ass, or mule can be landed from any foreign country unless accompanied by the certificate of a veterinary surgeon certifying that he examined the animal immediately before it was embarked or whilst it was on board the vessel, and that he found it did not show signs of Glanders. See also DOG.

POWERS OF POLICE INSPECTORS.—The police must enforce the Act and any Orders of the Board, and may without warrant detain anyone committing an offence against the Act. If the person so detained refuses his name and address, the police may apprehend him. The police may also detain any animal, vehicle, boat, or thing to which the offence relates, and require the same to be taken back to the place wherefrom it was unlawfully removed. Inspectors have all the powers of the police, and may at any time enter any land, shed, or building where they have reasonable grounds for believing that disease exists or has existed within fifty-six days, or that the carcass of a diseased or suspected animal is or has been kept, or has been buried or otherwise disposed of. If required, the inspector must state in writing his reasons for so entering. Offences against the Act are punishable by fine, and in certain cases in the discretion of the Court by imprisonment in lieu of a fine. [D. B.]

Diseases of Plants. See PLANTS, DISEASES OF.

Dishfaced, a term applied to an animal in which the forehead or face is slightly hollow or concave; so called after the form of an ordinary plate or saucer.

Dishorning.—The practice of dishorning has many advocates among feeders, who consider that animals are more peaceable and disposed to ruminate when deprived of their weapons of offence. The operation is held to be lawful in Scotland but not in England. The horns are divided by a sharp cross-cut or tenon saw, and the stump dressed with melted tar and bound with tow and string by the more careful and considerate operators; but in many cases a hot iron is used if hæmorrhage threatens, while in others the beast is left to shift for himself. As a rule no serious trouble follows, but in summer-time flyblow may be followed by maggots, which penetrate into the sinuses. The practice of disbudding or destroying the young horn in new-born calves by the application of a caustic alkali is rapidly taking the place of the more severe operation in adults. [H. L.]

Disinfectants.—A disinfectant is anything which destroys infection or purifies from infection. Since the germ theory has explained to us the cause and nature of infectious disease, great advances have been made in our knowledge of disinfectants. We now know that in order to prevent infection we must destroy the germs or living organisms which cause disease, and also their seeds or spores. In old days the views held as to disinfectants were very vague and inaccurate. For instance, perfumes which masked the smell of decomposing matters, and substances like charcoal, which act as deodorants by absorbing the evil-smelling gases given off by putrefying substances, were looked upon as

disinfectants. These substances as a rule do not really disinfect, they merely mask one of the unpleasant symptoms which frequently, but by no means invariably, accompanies infectious matter. Even at the present day, deodorants are often confounded with disinfectants.

There are various agencies by which disinfection can be brought about. Purely physical agencies, like heat and light, destroy germs of infection. Indeed heat is the most valuable of all disinfectants. All germs and their spores, as can all other life, can be destroyed by a moderate degree of heat. Many noxious germs are destroyed by a temperature below the boiling-point of water, and all germs and their spores are killed by a temperature a little above that of boiling water.

Disinfection can also be brought about in certain cases by purely mechanical means. Thus by efficient filtration all the germs can be removed from water. In certain cases, therefore, filtration may be used as a disinfectant.

The term 'disinfectant', however, is particularly applied to substances which destroy germs by chemical action. These are the chemical disinfectants, of which there are a great variety. Many strong poisons destroy lower forms of life as well as higher forms. Such a substance as corrosive sublimate (mercuric chloride), for example, is not only a powerful poison for higher organisms, but also a powerful disinfectant. On the other hand, many strong disinfectants, as for instance hydrogen peroxide and the permanganates, are not dangerous to higher organisms.

Disinfectants belong to many quite different classes of chemical substances, and bring about the destruction of germs by a variety of different chemical reactions. Among the non-metallic substances there are powerful and important disinfectants like chlorine, fluorine, iodine, bromine, and hydrogen peroxide.

The disinfecting action of good fresh air is due to the oxygen it contains, especially in the form of ozone. Among metallic compounds there are a great many disinfectants, such as the compounds of mercury, copper, and zinc, and the permanganates. A great variety of organic compounds also are used as disinfectants. Among these the best known are phenol or carbolic acid, and the closely related cresols, formaldehyde (which is commonly used under the name of formalin), chloroform, and certain derivatives of the terpenes.

The methods of action of disinfectants are various. Some, like the peroxides, the permanganates, and ozone, act by oxidation. Chlorine and the other halogens, which are among the most powerful disinfectants, combine with hydrogen and act as indirect oxidizing agents. On the other hand, sulphur dioxide and the sulphites have the opposite effect, and act as reducing agents. Many enter into direct combination with the albuminous substances of the organism and coagulate it, or otherwise render it incapable of performing the functions of life. Among these are such powerful disinfectants as corrosive sublimate, carbolic acid, and formalin.

Disinfectants vary greatly in power and rapidity of action. No absolute method of measuring disinfecting power has been or can be devised, since under one set of conditions one disinfectant may be more effective than another; but if the conditions are varied the results may be reversed. Further, the effectiveness of different disinfectants varies according to the kind of organism against which they are tried. Carbolic acid, for instance, is very effective against some organisms, but not nearly so effective against others.

[J. H.]

Dislocation.—By dislocation is meant the displacement of the articular ends of bones, or 'putting out of joint'. Ligaments and muscles hold the bones forming a joint together, and when dislocation takes place these structures are either sprained or broken. Displacements of the bones may occur during the period of gestation, and are then called congenital, or they may be acquired or accidental. Foals are often sacrificed on account of shortening of the flexors or extensors of the limb, whereby the animal is made to stand upon his toe, or tilt it up and rest upon the fetlock joint. Many of these cases are amenable to treatment, either by mechanical support in the right direction, or by surgical interference, and later, when it is possible to affix a shoe, by adding a long toe-piece, or providing a patten or high heel. Fast-growing 'leggy' young animals are liable to overshot or partially dislocated fetlocks, and to a luxation of the patella or stifle joint. In the latter case a weakness of the inner lateral ligament permits of temporary dislocation, which is remedied by further muscular contractions, and the bone is heard to jump back into its proper position with a clicking sound. Complete dislocation of a joint offers but poor prospect of perfect recovery, because we require in animals restoration to soundness, or at least so far as horses are concerned, or their maintenance during the time of enforced idleness exceeds their value. Milch cows may be worth treatment, or cattle intended for the butcher, if a front limb is the subject of injury, but if a hind one there will be so much wasting as to preclude the hope of reward. Dislocations complete and exhibiting great deformity may yet be treated successfully in a few instances, as when the accident occurs to the shoulder, whose point is not so much held in position by ligaments, which would be broken by the accident, as by muscular clothing, and if the great contractile power of these muscles can be overcome by placing the animal under complete anaesthesia, reduction may be effected without serious laceration, and recovery is comparatively quick and usually complete. The same may be said of a dislocated jaw, but such cases are rare. What we commonly meet with is the partial dislocations, and of these nearly all will affect the fetlock. If the front fetlocks of a working animal are overshot he is a bad subject for treatment, and complete reduction and restoration is hardly to be looked for, but rather an increasing deformity, progressing in proportion to the amount and pace of the work required of him. The practical horseman will not entertain the purchase of such a one; but may miss

buying a good servant if he declines a horse on account of upright or partially dislocated hind fetlocks, as it is found that these often remain workable without pain or serious alteration.

Treatment.—The application of blisters has been long approved, and can be recommended as tending to bring back the overshot bone and strengthen the strained ligaments. The biniodide is advised in preference to others where joints are concerned. [H. L.]

Dismissal. See MASTER AND SERVANT.

Dissolved Bones. See BONE MANURES.

Distemper.—Old-world writers used the term 'distemper' in regard to any prevalent disease of man or beast, but its employment is now confined to an infectious disease of dogs, due to some specific poison which gains access to the animal through the air passages. Puppies from three to seven months old are its special victims. After a year there is comparative immunity, although dogs much older are not wholly exempt. There is still doubt as to the organism which is responsible, and pathologists are not agreed, some having cultivated a bacillus of dagger shape with which they have reproduced the disease, and others attributing it to various *cocci* discovered in the discharges. The claim to establish immunity by a so-called 'vaccine' obtained by cultures of different micro-organisms has not been satisfactorily proved to the commission of veterinary experts over whom Sir John Macfadyean presided. The period of incubation is approximately four to seven days, but dogs take the disease in such varying degrees of intensity that the earlier symptoms of dullness may be overlooked, and the ordinary catarrhal signs, as tears overflowing and a watery discharge from the nostrils, do not at first proclaim the nature of the malady to the ordinary observer. Loss of appetite, prostration, a thickening of the mucous discharge, closing of the eyes with matter, a soft cough, and rapid wasting may lead to a low form of pneumonia, to gastro-enteritis and diarrhœa, presently becoming dysenteric and increasingly bloody until the patient is exhausted and dies; or other complications may supervene, as fits, paralysis, or chorea. The prospects of recovery would seem to depend chiefly upon the 'dose' or virulence of the attack, and the constitutional ability to withstand an exhausting illness; hence we find that inbred dogs, of great value from the show point of view, more frequently succumb than mongrels or common-bred animals.

Treatment of a disease with so many different manifestations must necessarily vary according to the symptoms, for it is only these which we can attempt to combat, pending the discovery of a specific for the destruction of the causal organism. Good hygienic conditions, as pure air, bodily warmth sustained by clothing, an apartment above the ground level and of sunny aspect, are essential. Beef tea and other easily assimilated nutriment, sponging away of the discharges with some simple antiseptic, as boric acid rendered emollient by a proportion of glycerine and diluted with water, and general regard to the dog's comfort are advised. The pulmonary symptoms are treated as when due to other causes, and the same may be said of the diarrhœtic form, such substances as bismuth, chalk, and catechu being employed as astringents, while the brain and spinal complications are combated by sedatives, bromide of potassium, ammonium, or sodium; or chloral, being in most favour as direct and quick in action. When St. Vitus's dance (chorea) follows an ordinary attack, there is but little prospect of complete recovery; the dog always after is subject to 'the jumps' more or less. The custom of giving a dose of castor oil and syrup of buckthorn at the commencement of the disease is endorsed by experience, and it may be that some of the distemper poison is thus removed from the system. It has not been proved that distemper does not enter by the alimentary tract like glanders and some other diseases, and if this is the case the early administration of an aperient would seem to be good practice. Distemper in cats has a general resemblance to that of dogs, but the short-haired original breeds are comparatively immune. Fancy breeds too closely related are frequent victims. [H. L.]

Distillers' Grains, also known as **Draff,** are very similar to brewers' grains, and are used for much the same purposes. The principal difference between them is that whereas brewers' grains generally consist entirely of the residual grains of barley left in the 'mash tun' after the bulk of the starch, sugar, &c., has been removed in the process of 'mashing', distillers' grains are prepared not from barley alone, but from other cereal grains as well, such as oats, rye, wheat, maize, and rice. Speaking generally, distillers' grains are of rather better feeding value than brewers' grains, the starch not being, as a rule, so fully extracted as is the case with barley in brewing. Consequently distillers' grains often fetch a somewhat higher price in the market. Distillers' grains are sold both in the wet state and as dried grains, the same process of artificial drying being made use of as with brewers' grains.

The following analyses represent the average composition of distillers' grains, both wet and dried:—

	Wet Grains.	Dried Grains.
Moisture	75·59	9·55
Oil	1·76	11·52
* Nitrogenous matters	4·66	25·20
Soluble carbohydrates, digestible fibre, &c.	13·27	38·78
Woody fibre	4·18	12·51
† Mineral matter (ash)	·54	2·44
	100·00	100·00
* Containing nitrogen	·74	4·03
† Including sand and silica	·25	·64

The principal use of distillers' grains is as food for milking cows; the dried grains are also frequently given to sheep.

DISTILLERS' REFUSE comprises the different matters left in the still after the distillation of

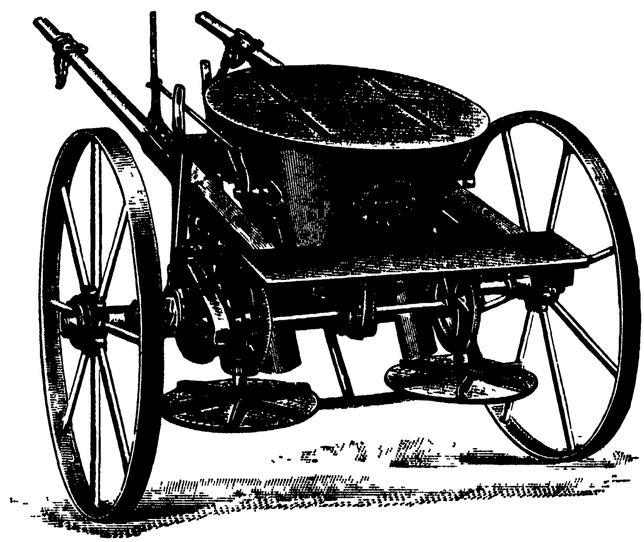
the alcohol. Many attempts have been made, *e.g.* by mixing with grain, molasses, &c., to obtain this refuse in a condition in which it can be used as food, but none have been practically successful. The waste yeast, which is another product from distilleries, has, however, of late been utilized, after pressing and drying, as a food, either alone or mixed with malt coombs, spent hops, and other materials. It has further been obtained, by evaporation *in vacuo*, in a condition in which it resembles meat extract, having a taste very similar to this, and being, indeed, used as a substitute for it.

Nor have the attempts at making distillers' refuse useful as a manure been very successful. The principal product is known as 'burnt ale', it having been somewhat charred in the process of preparation, in order to obtain it in a sufficiently dry condition for grinding into a powder. Mr. J. Hendrick gives the composition of this product as containing from 5 to 7 per cent of nitrogen, with phosphoric acid equal to from 12 to 15 per cent of phosphate of lime, and from 3 to 5 per cent of potash. It would appear, however, that the charring process prevents the decay of the organic matter, and hinders the manurial constituents from exercising their influence freely, for experiments conducted with it have not been very favourable to its use as a manure.

A manure is also made from the waste yeast by pressing it and then treating with small quantities of sulphuric acid, subsequently neutralizing with carbonate of lime, a porous mass being formed which can be easily dried and powdered (Julian L. Baker). The disposal of the washings from distilleries has been attended with great difficulty, and the turning of this waste into rivers has been a frequent cause of their pollution. No satisfactory process for dealing with these washings has as yet been evolved, though many attempts at a solution of the difficulty have been made. [J. A. V.]

Distomum hepaticum (the Liver Fluke). See FLUKES.

Distributor. — Distributors take many forms (see BROADCAST MANURE DISTRIBUTORS). The term 'distributor' is commonly applied to those machines which distribute seed-corn and manure broadcast, that is generally over the ground, and not in definite rows or drills; and as the mechanism is usually simple by reason of the simplicity of the work to be performed, they distribute over wide areas; drilling machines, however, are confined in their width to that of their frames, as the coulters cannot be conveniently set wider, or at any rate only slightly so. In the distribution of corn or manure, thorough and even spreading over the width dealt with is essential, otherwise the corn will come up too thickly in one part and too thinly in another, and manure will in like manner be unsatisfactorily spread. Among the features which have to be regarded is immediate delivery when the machine is started; otherwise when stopping for any cause in any part of the field the machine will get some distance forward before material reaches the ground. This is especially the case with machines in which the distribution is dependent upon throw or wind blast, as the material is not fully acted upon until speed has been attained sufficient to exert its proper force; in slowing down to stop there is also a diminution in force. Horses also are spasmodic in their draught, and as the speed of the fans or disks is in accordance with their speed, so the throw



Wallace's 'Universal' Distributor

is greater or less accordingly. The defects cannot be avoided unless there is a separate motor for distribution working with some independence, and this is very difficult to devise. Another feature to observe is that the manure does not become so compacted that it will not reach the devices to distribute it evenly. Hoppers which narrow towards the base are likely to cause this, so that the manure forms a bridge, and the machine may run for a considerable distance without making delivery. To avoid this, rotary forks, reciprocating sides, and other contrivances are employed, and while the manure is dry they are usually successful in dislodging it, but not always. The distributor should have a wide range of the quantity per acre that it will deposit, and in manure distributors this should be from as little as ½ cwt. to a ton. The alteration is generally effected by changing the speed of 'feed' or rate of extraction of the material from the hopper, and by opening or closing ports to allow a greater or less quantity to pass through. Distributors of several kinds to spread farmyard manure have been devised, but they have not come

into general use; and at the competitive trials of the Royal Agricultural Society in 1908 no awards were made. The most popular forms are those in which a sliding false bottom, or a bottom with an endless chain to which are attached cross-pieces, is employed to bring the manure to the rear of the wagon, where rotary forks draw it out and spread it. It is probably because in most cases separate vehicles purposely devised are necessary, requiring the displacement of wagons or carts existing on the farm, that farmers have not given more attention to them; moreover, hand-spreading with a fork is work that can be done at odd times, and when weather is not favourable for other kinds of work.

Distributors for sowing powders such as lime, to dust over plants as a preventive against insect attacks, are generally provided with a wind blast, as in the case of the Strawsonizer, and are well suited to the purpose. [W. J. M.]

Ditch, and Ditching Machine.—Ditches play an important part on the farm, providing watercourses to clear the land of superabundant water, fences to hold up farm stock, and channels to convey water for the animals. Prejudicially they occupy land that might otherwise be cropped, and, especially if not kept well cleaned out, act as nurseries for the snails which are favourable hosts for the liver fluke. Ditches in themselves act as drains, as water percolates into them from their sides, but they are largely made use of as outfalls into which water is emptied by land drains; and as neglect to keep ditches clean very frequently leads to large systems of land drainage being rendered useless owing to the outlets being blocked, the importance of keeping ditches well scoured out cannot be too strongly advocated. During the dry years from 1868 to 1878 it was strongly urged that fields should be enlarged so as to admit the use of the steam plough. During these years many ditches were dry and appeared useless, and a vast number were filled in,—a mistake which the wet seasons commencing in 1879 quickly and emphatically showed, as large areas of land were flooded, in spite of the drain pipes which had been placed in the bottoms of the ditches to give relief when the ditches were filled in. It may be taken as a safe axiom that ditches have been dug because experience has shown that they were needed, although during normal seasons their value may not be apparent. At any rate, great reserve should be exercised in filling them in. Many positions appear to be quite safe from any risk of flooding, which are not so in abnormal circumstances. Ditches are expensive to dig, and therefore they are rarely dug without a substantial cause. It is a common error in digging ditches to allow too little batter or slope. It is generally accepted that the angle of the different soils with the horizontal line is as follows:—

Gravel, 40°.	Shingle, 39°.
Dry sand, 38°.	Rubble, 45°.
Wet sand, 22°.	Clay (drained), 45°.
Vegetable earth, 28°.	Clay (wet), 16°.
Compact earth, 50°.	Hard rock, vertical.

In deciding the angle of repose for the sides of a ditch it is, however, necessary to have regard to the influence of frost, and weather generally, and to the force of the water which may be expected. Frost is very destructive, especially before the sides become well covered with vegetation. When a bank becomes undermined by water there is always risk of a slip, consequently curves should be made as gently as possible. Rats and rabbits are very destructive to the banks of ditches, as also are moles. Ditches are generally dug by hand labour, though it is not uncommon to employ a plough to loosen or turn out the top furrows. Specially designed ditching ploughs, to be hauled by steam-cultivating engines provided with a windlass and steel rope, are also available, and these are effective. Excavating machines of various types have been devised for opening channels, but they are more serviceable for large drainage works and irrigation systems than for ordinary farm ditches, with which manual labour is competent to deal conveniently. [W. J. M.]

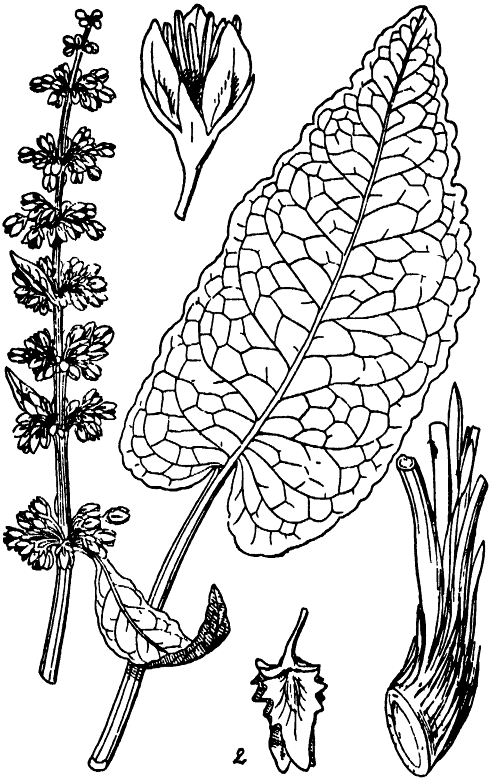
Dock (Rumex).—All the plants known as Docks are taprooted perennials belonging to the

Curled Dock (*Rumex crispus*)

1, Flower. 2, Fruit. 3, Pistil. 4, Section of pistil.

nat. ord. Polygonaceæ. They are identified (1) by their large simple leaves, each of which has a special outgrowth at its base in the form of a sheathing tube (*ochrea*) round the stem; and (2) by their fruits, which are three-faced nuts, each

covered in by three flat scales (*sepals*). Since the root is stout and strikes deep into the ground, it can be removed only by the application of considerable power. When thus strained, however, the root usually breaks, leaving fragments



Broad-leaved Dock (*Rumex obtusifolius*)

1, Flower. 2, Fruit.

behind in the ground. These fleshy root fragments strike anew, produce buds which become shoots, and ultimately new Dock plants. Hence for extirpation repeated pulling is necessary—one removal is not enough. When Dock roots are cut into pieces by the plough, it must be remembered also that each root piece can propagate, and so these cut portions must be carefully removed. To prevent spreading by seed, the air parts must be removed early, before the fruit is ripe, and any clover or grass seeds sown out should be free from Dock impurities.

Although Docks are often troublesome weeds, still they have, at times, their uses. The roots of the Curled Dock (*Rumex crispus*) and of the Water Dock (*Rumex aquaticus*), for example, are used by herbalists in the cure of skin diseases.

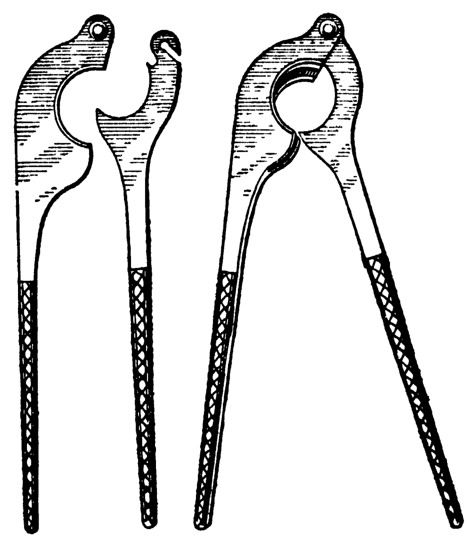
The prevalent species of weed Docks are: (1) Curled Dock (*Rumex crispus*), (2) Broad-leaved Dock (*Rumex obtusifolius*).

Curled Dock has a stem 2 or 3 ft. high. At its base the ground leaves are long (6 to 8 in. often) and narrow, curly and crispy along the edges. At the apex of the stem the flowers appear in crowds, and the leaves are now reduced to mere scales or bracts. When in fruit, each flower produces a single three-faced nut, 2½ mm. long by 1½ mm. broad; the shell is glossy and reddish-brown; the investing scales are more or less heart-shaped, without fringes of sharp teeth, and one of the three has a conspicuous coloured swelling along its midrib. This weed is frequent in pastures.

Broad-leaved Dock has the same height as the curled species, but the ground leaves are broader in proportion to the length, often 8 or 9 in. long by 3 or 4 in. broad; besides, the point of the ground leaf is rounded off and not acute. When in fruit, the three-faced nut is very like that of the Curled Dock, but the investing scales never have the shape of a heart, and the edges are always provided with sharp teeth. In pastures this weed is very common, indeed it is often found associated with the Curled Dock.

[A. N. M'A.]

Docking. — The shortening of the tail is known as docking, and is practised upon certain breeds of horses and dogs, as well as sheep, the custom being wellnigh universal with regard to the latter animals. Fashion prescribes a very short dock for the hackney, and convenience dictates for the hunter a tail that will not hang up by means of long hair. Many harness horses have an inconvenient habit of swishing the tail in such a manner as to catch the reins, and serious accidents have resulted. Much controversy has arisen as to the need or otherwise of docking, and many prosecutions have taken place



Docking Instrument (Arnold & Sons)

on account of cruelty incident to the practice; convictions being recorded where due skill and care have not been exercised, but an acquittal has usually followed a charge brought against a qualified veterinary surgeon. No High Court decision has been obtained, and docking is still done at some risk to the owner and operator as regards horses, although by common consent the need of the operation is conceded in sheep,

to prevent accumulations of fæcal matter and flyblow. If the division of the tail is effected by a clean and powerful instrument at a point selected between the caudal bones, it may be assumed to cause but little pain. Searing with a hot iron and powdered resin no doubt is a painful proceeding, but the most aseptic, and calculated to prevent subsequent hæmorrhage. A ligature above the seat of operation and a tampon of tow soaked in carbolized oil is employed by the more humane surgeon, and removed next day when hæmorrhage is no longer feared. It is, however, a fact that tetanus (lockjaw) more often follows the use of the ligature than the actual cautery, whether after castration or docking. The younger an animal is docked the less severe is the performance, as the tissues are softer, more easily divided, and the stump disposed to heal.

A more pointed and better-shaped dock or stump is left when the operation is performed in foals and puppies, the latter seeming to suffer no more than the most temporary inconvenience. Lambs are commonly done at a few days or weeks old, and no precautions taken to prevent hæmorrhage. Cases of tetanus occur which are undoubtedly due to neglect of such simple precautions as dipping in tar, a custom adopted in hot countries with excellent results. [H. L.]

Dodder (Cuscuta), the name of a genus of parasitic plants which often do great damage to such crops as Red Clover and Flax. Unlike most vegetable parasites, such as smut in corn, the Dodders are not fungi, but flowering plants. When seen at work on Red Clover, for example, the parasite appears as a yellow fleshy thread, wound in a spiral line around the clover. This spiral thread is a twining stem, but unlike other twining stems, *e.g.* of the Bindweed (Convolvulus), this Dodder stem is leafless. In fact, for the Bindweed the support serves a purely mechanical purpose, but for the Dodders a mere wooden stake is useless; the parasite must entwine something actually living, something from which it can draw a full supply of food and drink. Such a living support is called the *host* of the parasite. When all the facts are taken into account, we cannot but regard the Dodder as a Convolvulus which has taken to a parasitic mode of life, and hence Dodders are said to belong to the nat. ord. Convolvulaceæ, and for greater precision to the parasitic division of the order. Since the parasite gets all its food from the host, ordinary green leaves would be useless, inasmuch as the special duty of a green leaf is to manufacture the food required for sustenance. There are, however, traces of leafy ancestors, for, on the threadlike stem, rudiments of leaves, taking the form of very minute colourless scales, may be found.

Now what about the roots? An ordinary Convolvulus has to use them for exploiting water and minerals from the earth, but a parasitic Convolvulus has to exploit food and drink from the air parts of the supporting host, and has no use whatever for a root in the ground. Hence the Dodder, as it twines round, inserts into the very substance of its hosts at appropriate intervals special sucking roots (*haustoria*). By means of these the parasite withdraws as much food and drink as it can get,—indeed to such an extent that the host preyed upon ultimately dies from sheer starvation. Small wonder, then, that the farmer seeks to exterminate such a pest. In this connection the thinness of the threadlike stem is quite remarkable; from the minimum amount of material the maximum amount of stem length is secured, and the maximum amount of host brought within range. To secure new hosts and still wider range, branch threads sprout out at the sides of the main thread, and these winding round in the air (*revolving nutation*) like a blind man groping after something, come into contact with new hosts. This branch stem is specially sensitive to contact, and that secured, the branch immediately bends round, inserts a sucking root, grows and twines, and inserts more sucking roots till the new host is well within its grasp. Now the connection between the offshoot and the parent dies away, and thus we come to have a new parasite, independent, and acting on its own account. Again, no wonder that Dodder is sometimes called *Devil's guts*, for it blasts whatever it touches, and spreads destruction all around.

In connection with the extermination of these Dodders, we must enter into some details concerning the reproductive process. When this is commencing, minute ball-like bodies appear at intervals along the twining stem. Each ball is a cluster of flowers, composed of about fifteen flowers on an average. Speedily the flower ripens and reaches the fruiting stage. This fruit is composed of a dry, two-chambered seedcase containing two seeds per chamber, that is four seeds per flower. Accordingly, a flower ball of fifteen flowers is capable of yielding sixty seeds. Under favourable circumstances, then, the Dodder must be gifted with extraordinary powers of reproduction by seed. These favourable circumstances are found in the warmer climates, such as southern England, southern Europe, the Argentine in South America, &c. But in the colder climate of Scotland, Dodders usually fail to bring their seeds to maturity, and the climate itself curtails their powers of destruction. In autumn, when Dodder fruit is ripe, the seedcase splits across and allows the seeds to fall out and reach the ground. Now the Dodder plant dies; it exhausts itself completely in seed production, and is accordingly a true annual.

The seed of Clover Dodder is a small body, a little over 1 mm. in diameter, which looks like a tiny piece of grey earth or clay, but, unlike clay, when pressed beneath a knife blade it does not crumble. The shape is like a fourth of an orange. To see the contents the seed is softened by boiling in caustic potash, squeezed between two glass plates, and then examined under a pocket lens. Now we notice within the seedcoat a cylindrical yellow body like a little worm, coiled in three turns round a transparent substance in the centre. The coiled cylinder is the embryo plant, and the central substance the food (*endosperm*) for nursing the embryo during the period of germination. The germination pro-

cess begins late in spring: the seedcoat bursts, the embryo feeds on the endosperm and uncoils, one end grows down as a holdfast in the earth, while the other end grows up into the air in search of a host to prey upon. To catch the host, the end in the air revolves, and whenever contact is secured, the holdfast in the ground dies away; now the Dodder is a parasite pure and simple. It twines round and exploits its host, it branches out and finds new hosts, it forms its flowers and fruits, and then dies—all in the course of a single season.

Living thus, it is easy to understand the preventive measures that should be taken against the spread of Dodder. The best plan is to dig up the infected part of the crop, so as to form

Clover Dodder (*Cuscuta Trifolii*)

a circle considerably beyond the infected patch. These dug-out plants should be carefully burnt, for if even a piece of the parasite gets into contact with a host it may begin to grow, and thus form a new centre of infection. Care should also be taken that any seeds of plants liable to attacks of Dodder are free from Dodder, and this is best secured by a written guarantee from the seed seller. Timothy seed should be specially watched, for when screened off from Clover, the Dodder seeds pass through the sieve along with the Timothy, being nearly of the same size.

Spraying with a 15-per-cent solution of sulphate of iron has proved successful in Germany, in destroying Dodder in Clover. The spraying should be done with a sprayer, so that the liquid is forcibly projected on to the ground in order to reach the Dodder threads which are attached to the Clover stems beneath the ground surface. In Cape Colony, spraying with a solution containing ¼ lb. arsenite of soda to every 5 gal. of water has been found satisfactory in destroying Dodder in Lucerne.

Numerous species of Dodder are known, indeed botanists distinguish forty or fifty. The four common species are:—

1. Clover Dodder (*Cuscuta Trifolii*), represented in annexed illustration, has yellow twining stems, and small white flowers with a short calyx only as long as the tube of the corolla. Parasitic on Red Clover.

2. Lesser Dodder (*Cuscuta Epithymum*) has reddish twining stems, and white flowers with a calyx very short, shorter than the tube of the corolla. Parasitic on Thyme and small shrubs.

3. Flax Dodder (*Cuscuta Epilinum*) has pale-green twining stems, and whitish flowers with a fleshy calyx nearly as long as the corolla. Parasitic on Flax.

4. Greater Dodder (*Cuscuta europæa*) has reddish twining stems, and large clusters of yellowish flowers with a long calyx, much longer than the corolla. Parasitic on various herbaceous plants. [A. N. M'A.]

Doddies, a local name formerly applied to the Polled Angus cattle, and distinguishing them from the Buchan cattle, which were designated 'Humlies'.

Dog.—Domesticated breeds within the genus Canis, which includes wolves, jackals, and foxes, are called dogs; and the name is also given to wild dogs, such as the bush dog (*Icticyon*) of British Guiana, the racoon-like dog (*Nyctereutes*) of China and Japan, the long-eared dog (*Otocyon*) of Africa, and the dholes (*Cyon*) and other Eastern dogs. These seem to require separate genera, nearly related to Canis, within the family Canidæ. The difficult case of the dingo, which first appears in Pleistocene deposits in Australia, is considered separately. The genus Canis has a cosmopolitan distribution, being represented all over the world except in New Zealand and Madagascar, and it is probable that domestication took place independently in different regions and from different wild species. Thus, though the domestic dog is often called *Canis familiaris*, as if it were a single species, its origin is more probably multiple. Darwin pointed out resemblances between various types of domestic dog and wild dogs in the same or in a neighbouring region. It has been shown by Nehring that the Incas of Peru had, before the arrival of the Spaniards, at least three breeds of dogs, corresponding to our Dachshunds, and so on; it is likely that these arose from American species, such as the Prairie Wolf (*C. latrans* and *C. occidentalis*). In widely separated regions there is evidence that dogs were in very ancient days associated with man on the friendliest terms, being sometimes buried with him; and as the remains point to forms differing from one another and from our modern breeds, there is again a hint that different races of men domesticated different species of Canis. Some of the larger breeds may have originated in wolves (*Canis lupus*), some of the smaller in jackals (*C. aureus*); while the Bunasu (*C. primævus*) and the Indian Wolf (*C. pallipes*) have also been suggested as likely ancestors. The formation of different breeds by selection and the admixture of these in the course of ages have probably complicated the genealogy of domestic dogs beyond all hope of unravelling.

Although there are some authorities, such as Prof. Th. Studer, who maintain the thesis that all domesticated dogs have had a common ancestry, *e.g.* in the diluvial wild dog (*Canis ferus*), just as domesticated pigeons may be traced back to the Rockdove (*Columba livia*), the great majority adopt the view first clearly stated by Pallas (1780), and defended in detail by Darwin (1868), that domesticated dogs have evolved from several wild species. In any case, it is certain that the number of breeds has increased greatly within historical times, and as many as 180 are now recognized! The differences in size, in the proportions of parts, in the structure of the skull, in the covering of hair, and so on are extraordinary; the contrast between a tiny Bolognese dog 22 cm. long and a St. Bernard of six times that length is diagrammatic. Some of the most important breeds of dogs are alluded to in separate articles. They may be arranged in groups, *e.g.* those represented by Terriers, Sheepdogs, Greyhounds, Newfoundlands, Pariahs; but this is another problem of very great difficulty.

[J. A. T.]

Dogs, Laws regarding.—The common law with regard to liability for damage inflicted by dogs has already been referred to (see ANIMALS, LAWS REGARDING). The common law has, however, been supplemented and modified by statute. By the Dogs Act of 1871 it is enacted that if a dog is dangerous and not under proper control, the Court may direct the owner to keep the dog under proper control, or may order it to be destroyed. It has been decided that the order for destruction may be made without the option of keeping under proper control. It has also been decided that 'dangerous' meant dangerous to animals as well as to man, and this has now been expressly enacted by the Dogs Act, 1906.

Moreover, considerations of public policy have made it necessary to make special provisions by statute for the case of injuries by dogs to cattle. The main distinction between the case of injuries by dogs to human beings and to cattle is, that in the latter case it is not necessary for the owner of the cattle to prove a previous mischievous propensity in the dog, or the owner's knowledge thereof, or that the injury was attributable to neglect on the part of the owner. The law is now regulated by the Dogs Act, 1906, which amends the enactments relating to injury to live stock caused by dogs. By this Act it is provided that the owner of a dog is liable for injury to cattle without the necessity for proof of a previous mischievous propensity in the dog, or the owner's knowledge of such propensity, or for showing that the injury was attributable to neglect on the part of the owner. The occupier of any house or premises where the dog was permitted to live or remain at the time of the injury is presumed to be the owner, and is liable for the injury, unless he proves that at the time he was not the owner of the dog. If there are more occupiers than one in the premises, the occupier of the part in which the dog was permitted to remain shall be presumed to be the owner.

As already mentioned, it has been decided in England that a dog which was proved to have worried sheep was dangerous within the meaning of the 1871 Act, and that therefore it could be destroyed. The question is now put beyond dispute by Section 1 of the Act which we are considering, whereby it is provided that where a dog is proved to have injured cattle or chased sheep, it may be dealt with under Section 2 of the 1871 Act as a dangerous dog. The Board of Agriculture are empowered to make Orders about dogs: (1) for prescribing and regulating the wearing by dogs, while in a highway or a place of public resort, of collars with the name and address of the owner inscribed on the collar, or on a plate or badge attached thereto; (2) with a view to the prevention of the worrying of cattle, for preventing dogs straying during the night; and (3) for authorizing a local authority to make regulations for either of these purposes.

Acting on the powers thus conferred, the Board has issued an Order giving local authorities power to make regulations as to the wearing by dogs, while in any place of public resort, of collars with the owner's name and address thereon, or on a plate or badge attached thereto. But this provision is not to extend to packs of hounds, or dogs while used for sporting purposes, for the capture or destruction of vermin, or for driving or tending sheep or cattle. Any dog not having such a collar on may be seized and treated as a stray dog under the 1906 Act. Moreover, the owner or person in charge of the dog is guilty of an offence. Meantime the Board has not authorized local authorities to make regulations for preventing dogs straying at night. This Order supersedes all previous muzzling regulations.

By the 1906 Act, the police are empowered to seize stray dogs and detain them until their owners have claimed them and paid all expenses, under the conditions as to notice to the owner, if known, enumerated in the Act. If the dog is not claimed within seven days after notice, it may either be sold or destroyed. No dogs so seized may be given or sold for the purposes of vivisection. A register must be kept by the police, giving particulars of the dog, the date of its seizure, and the manner in which it is disposed of. The dog while detained must be properly fed by the police officer or other person in charge. Anyone taking possession of a stray dog must either return it immediately to its owner, or at once inform the police. The expression 'cattle' in the Act includes horses, mules, asses, sheep, goats, and swine. Provision is made for the burying of carcasses, and any person who shall knowingly, and without reasonable excuse, permit the carcass of any head of cattle belonging to him to remain unburied in a field or other place to which dogs can gain access, shall be liable on conviction under the Summary Jurisdiction Acts to a fine not exceeding forty shillings.

The Act also makes provision for the exemption of sheepdogs, &c., from payment of the excise licence. Subject to the exemptions to be immediately referred to, everyone who keeps a dog must annually take out a licence, the cost whereof is 7*s.* 6*d.* This licence is granted in

favour of the person who takes it out, and not in favour of the dog. That is to say, if a person who has taken out a licence sells one dog and acquires another, he does not require to get another licence; but if a person who has not hitherto kept a dog buys one, he requires immediately to take out a licence, although the late owner of the dog has a licence and keeps no dog. The following are the exemptions under the Dog License Act: (1) Blind persons do not require a licence for a dog kept and used solely by them for their guidance. (2) Farmers and shepherds keeping sheepdogs are entitled to exemption for dogs which are used solely for tending sheep or cattle, or in the exercise of the calling of a shepherd. Two or more dogs, but not exceeding in all eight in number, may be kept, in proportion to the number of sheep on common or unenclosed land. In order to obtain this exemption a declaration has to be filled up, and in return a certificate of exemption received from the Commissioners of Inland Revenue. By the Dogs Act, 1906, the granting of a certificate requires the previous consent in England of a petty Sessional Court, and in Scotland of the sheriff or sheriff-substitute having jurisdiction in the place where the dog is kept; but the consent shall not be withheld if the Court is of opinion that the conditions for exemption mentioned in the 1878 Act apply in the case of the applicant. It is not necessary for the applicant for exemption to appear in person, unless the application is opposed, and the Court considers the appearance of the applicant necessary for the proper consideration of the application. No fee is payable in respect of the application or consent. Until 1st January, 1912, this provision as to obtaining the sheriff's consent shall not apply in Scotland to any application for the renewal of a certificate of exemption in force at the date of the passing of the Act. (3) No licence is required for any dog under the age of six months, and where the owner or master of a pack of hounds has taken out proper licences for all the hounds entered in any pack kept by him, it is not necessary for him to take out a licence in respect of any hound under the age of twelve months which has never been entered or used with the pack.

By the Rabies Order of 1897 anyone having under his charge a dog (or a horse, ass, or mule) affected with, or suspected of, rabies, must with all practicable speed give notice to a constable, and, in the case of a dog, it, and any dog bitten by it, may be slaughtered by order of the local authority. No compensation is payable to the owner of the slaughtered dog.

By the Importation of Dogs Order of 1901 it is provided that no dog may be brought into Great Britain from any other country except Ireland, the Channel Islands, and the Isle of Man, unless a licence to land it be first obtained from the Board of Agriculture. If such a licence be obtained, any dog so imported must be detained for six calendar months, at the owner's expense, in the premises of a veterinary surgeon previously approved in writing by the Board for that purpose. During such period the dog may not be moved from the place of detention except to another place of detention, or to a vessel for exportation, and in either case only with a licence of the Board authorizing such movement. If an imported dog is not detained as provided by the Order, any inspector of the Board of Agriculture may seize it and place it in a place of detention. If the owner does not, within ten days after the period of detention specified in the Order, claim the dog and pay the expenses of detention, the Board may destroy or otherwise dispose of the dog as they think expedient. Dogs which have been taken out of the country are subject to the provisions of this Order on reimportation. [D. B.]

Dogs, Management of. — The three great points which demand the attention of dog-owners are feeding, housing, and general management, which of course includes such matters as exercising, washing, physicking, and other kennel details of routine.

It may at once be laid down as a general rule that most dogs are either overfed or else injuriously fed. Very few animals, excepting, of course, young puppies, toy dogs, ailing adults, and 'shy feeders', require to be fed more than twice a day; in fact, many dogs thrive better upon one meal; but if two are provided, a light early meal and a more substantial one at night will be found to be amply sufficient. Under no circumstances should the food be left after the dog has finished eating; the vessel containing it must at once be removed. The appetites of dogs vary very considerably, and some dogs will thrive well upon an amount of food upon which others would almost starve. There is the 'bad doer', who eats well, but does not thrive. There is the gross-feeding, greedy dog, who, if he gets all he wants, will soon become so fat as to be both useless and unsightly, in addition to which he will deprive his kennel companions of their fair share of the day's rations if they feed in company. Consequently someone should be present at meal times, and no dog should be given more food than is good for him.

Regarding the quality of the food supplied, the best is the cheapest, and the most satisfactory. A really good food goes further and is more nourishing than a cheap one, this being particularly the case when biscuits are used in the kennel, as makes of indifferent quality not only fail to nourish the dogs, but often upset their stomachs. In short, there is as great a difference between the value of such biscuits as those manufactured by Spratt's Patent and the badly baked compounds of musty flour which are often sold for dogs' food, as there is between the finest beef or mutton and the most undesirable samples of horse flesh upon which some owners feed their dogs. Too much importance, therefore, cannot be attached to the quality of the meal and the biscuits upon which dogs are fed, and as the animals should subsist principally upon a farinaceous diet the fact should be remembered.

A certain amount of flesh is, of course, desirable, and the best biscuits usually contain this in stated proportions, and also a percentage of vegetable food in the form of beetroot, which is an excellent thing for dogs, and keeps well for a considerable time. Sound horse flesh in modera-

tion is very useful as a change, especially in the case of the larger varieties and during the cooler months of the year; but when the weather is hot, meat is liable to heat the blood and bring about eruptions of the skin. Beef and mutton, if procurable upon reasonable terms, are excellent foods. Speaking generally, although an occasional meal of raw flesh is rather beneficial than otherwise, as a rule it is better to boil all the meat that dogs partake of. It is better for them, and also provides a supply of broth, which is useful for mixing up with biscuits or meal on the following day. It may here be pointed out that food which is cooked for dogs should never be allowed to stand in the copper in which it is boiled, as if it is, it will be almost certain to turn sour; and the chances of this will be increased if green vegetables are added, as they always should be. Bullocks' or sheep's heads are first-rate for the purpose of making broth, and the bones can be given to the dogs afterwards, but care should be taken to prevent fighting in the kennel over the division of these.

There is a great advantage attached to bones, as the gnawing of them not only assists in cleansing the dog's teeth, but also promotes the secretion of saliva, and consequently assists digestion. Dry biscuits achieve very similar results, and may be given at least once or twice a week,—though, occasionally, highly fed, pampered dogs decline them. Both bullocks' tripe and sheep's paunches are liked by dogs, and although they do not contain much nourishment they provide a nice cooling food. But they should always be given cooked, or at all events well scalded, as they frequently contain impurities, such as the larvæ of insects, which might seriously affect their health.

Regarding meal, it may be said that oatmeal is by far the best, for although it is apt to heat the blood in the case of dogs which are unaccustomed to it, this food is the most nutritious; but its quality must be good. Stale bread may be given, but it is generally difficult to obtain, and if given with broth or milk sometimes upsets the stomach. Cows' milk, if given, should be diluted to the proportion of about 2 parts water to 3 of milk; but unless this can be procured in a good form it is rather an uncertain food for dogs, as its quality varies considerably. On the other hand, there are some makes of dried milk on the market, and the best of these are most admirably adapted for kennel purposes, the brand containing the addition of malt being invaluable for all puppies as well as for ailing adults.

Scraps from the table, provided that the addition of vegetables and bread is not omitted, are useful in the case of the smaller breeds; but an owner is committing a very great mistake if he only selects the choicest pieces of meat and the richest gravy for his dog to eat. Finally, the question of water has to be considered, and this is a far more important subject than many people imagine it to be. The trough should be kept absolutely clean, and the contents changed at least twice a day. Nor should the water a dog has to drink be allowed to stand in the sun, for if it is, a derangement of the bowels is very likely to ensue. Moreover, if a dog drinks contaminated water, his energy, if not his health, is sure to suffer.

The question of housing is often neglected. What the dog really requires is a dry, light, weather-tight home, adequately ventilated and properly floored, which will be warm and free from draughts in the winter, and not liable to become overheated in hot weather. The new design of kennel with the entrance at one side is a vast improvement upon the old pattern with the entrance at the front. A very serviceable home for a dog can be formed out of a barrel, with a hole cut in one end to allow the dog to go in and out; but in such cases the entrance should be turned towards the wall, in order to ensure protection from the weather.

To most houses there is attached a shed or some similar building which is capable of being converted into a kennel. Assuming that the size of this building permits, a wooden bench should be erected about 18 in. above the floor for the dogs to sleep upon. The best floor is either cement or asphalt; the former is preferable for an outside yard, as the sun does not soften it. Coarse sawdust or peat moss is laid upon the floor to assist in keeping the place sweet and to facilitate cleaning operations, and there should be ventilators high up on the sides which can be opened or closed, so as to ensure a sufficiency of air without producing a draught. It is never desirable that a dog should be kept chained up if it can possibly be avoided, such restriction upon the liberty of growing animals being particularly unadvisable, as in their efforts to get free they are liable to wring their shoulders.

Exercise is not merely desirable, but also necessary for the health of the dog. At least half an hour a day should be allowed for exercise, and if after the principal meal, it will be all the better, as it will enable the dog to open his bowels in comfort. Cleanliness, not merely of the kennels but of the animals' bodies, is another matter that demands attention, though a too frequent application of soap is calculated to soften the coat, and hence depreciate the merits of many breeds. The application of flour that has been well baked in the oven, and well rubbed into the jacket, will remove a good deal of dirt and make a dog look quite presentable; but there are times when a regular bath becomes a necessity. In such cases the dog should be made to stand in a large bath or tub of fairly hot water. His coat should be thoroughly saturated, and soap should then be well rubbed in. The coat should then be swilled until the soap is out of it, and a douche of clean water will complete the operation. After this he should be well dried, and permitted to roll on some clean straw. If allowed to run loose or return to a dirty bed, the good effects of the bath will be speedily obliterated. When dry, the coat should be well brushed out, and if necessary it may be also combed, but as a rule the less combing the better, as the teeth are liable to pull out tufts of hair and irritate the skin.

In conclusion, it may be pointed out that the correct way to administer liquid medicine is to

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Scotch Terrier

place the dog between the legs with its back towards you, holding the head between the knees in an upward position. Then pull the lips on one side away from the teeth, so as to form a sort of funnel into which the fluid can be poured, the jaws being kept closed by the disengaged hand. If the head is kept steady the medicine will soon be swallowed, but if he is a troublesome animal it is a wise plan to obtain the services of an assistant to hold him. [v. s.]

Dogs, Varieties of.—Anomalous though the statement may appear to be, it is unquestionably the fact that although the usefulness of the canine race has considerably decreased of late years, its popularity amongst the public has never been as great as now. With the possible exceptions of such varieties as the Foxhound, the Harrier, the Beagle, the Collie, the Old English or Bobtailed Sheepdog, the Retriever, and the Field Spaniel, and to a lesser extent the Greyhound, Deerhound, Pointer, Setter, and certain breeds of Terrier, the services of the canine race are not devoted to useful or sporting purposes by the inhabitants of this country.

Consequently the division of the different breeds into two divisions of about equal strength, as is the usual custom amongst the promoters of shows, may be regarded as a somewhat arbitrary and altogether unsatisfactory solution of the difficulty that beset them. Undoubtedly many of the breeds which are included in the so-called classification of sporting dogs have no substantial claims to be there, if their present status and the uses to which they are adapted are taken into consideration. Their progenitors doubtless may have been, and in many instances unquestionably were, entitled to the distinction, but of late years a considerable change has taken place in the methods under which some sports with which dogs are associated are conducted, and hence the desirability of arranging a new classification of the canine race.

At the same time, there is no necessity for abolishing the two broad lines of distinction which have been drawn between the sporting and non-sporting varieties. It is rather preferable that the two categories, for the purposes of this work at all events, should be subdivided. Consequently it may be suggested that the classification should be as follows:—

Sporting Dogs.—*Division I.*—Foxhounds, Harriers, Beagles, Otterhounds, Greyhounds, Deerhounds, Pointers, Setters, Retrievers, and Field Spaniels. These practically exhaust the British varieties whose services are utilized for the taking of game; but there remain also the French Basset Hound, and to a minor extent the German Dachshund, though the latter is perhaps more of a terrier; but neither of these is much utilized for sporting purposes by British owners. At the same time, it may be added in justice to the Basset Hound that he is a grand hunting dog and the possessor of a most remarkable faculty of scent, which statements received ample confirmation when some of his admirers established a pack of drag Basset Hounds in this country a few years ago. No doubt, too, the Bloodhound will be regarded by many as possessing substantial claims to be included in the category of the leading sporting breeds; but although one may fully recognize the qualifications possessed by this most magnificent hound, it must be admitted that so far as hunting purposes are concerned the occupation of the Bloodhound has ceased to be. Lord Wolverton a few years ago possessed a pack of these hounds, but since it was broken up the marvellous hunting powers of the Bloodhound have practically remained in abeyance, though proof positive has been provided of his retention of them in the course of the field trials which have been held. The claims of the Bloodhound to be included in the category of modern sporting field dogs must depend, therefore, more upon his reputation in the past than upon his actions of the present, though it may once more be pointed out that his abnormal scenting and tracking powers have been fully maintained.

Sporting Dogs.—*Division II.*—This division includes many members, in fact the vast majority of the Terrier family, whose services are more or less utilized for the hunting and extermination of vermin. It must not be imagined, however, that all the varieties which are known as terriers are qualified to be included in the honourable category of sporting dogs. The silky-coated Yorkshires and Clydesdales would be sadly handicapped by the delicate texture of their jackets if called upon to do a day's hard work on the riverside and underground. The almost extinct Black and Tan Terrier and the still more rare White English Terrier were never robust or dead game enough to be employed in the extermination of vermin. The various breeds of toy terriers, moreover, cannot by any stretch of imagination be regarded as being qualified for inclusion in the sporting classification.

The Non-Sporting Category is susceptible of division into two or more branches, which may be referred to as dogs for guarding life and property, utility dogs, companionable dogs, fancy breeds, and toys. Included in the first of these subsections the Mastiff and the Bulldog stand pre-eminent; and, with no disrespect to his claims to be incorporated a member of the sporting classification, the Bloodhound possesses ample qualifications to be regarded as a protector of his owner and his home, if only on account of the exceptional powers he possesses for tracking a marauder after he has left the premises. Such a variety as the Schipperke, though small in size, is entitled to inclusion in the category of guardian dogs, as his natural alertness of disposition has been encouraged for generations past by the barge-owners of Holland, who utilize his services for the protection of the merchandise they carry through the canals. The Pomeranian likewise is a remarkably vigilant breed when the safety of his master's property is entrusted to his keeping; whilst the abnormal courage and gladiatorial propensities of the Bull Terrier constitute him a most valuable guardian of dwelling-houses and their contents.

The utility varieties of the non-sporting division may be limited to the Collie and the Old English or Bobtailed Sheepdog, the services of which are still highly appreciated by those

who are connected with the control of live stock. In fact, the marvellous intelligence with which the above breeds are naturally gifted shows no signs of diminution, but if possible the reverse, though on the other hand there are nowadays many hundreds of specimens of each which fulfil no useful purpose at all, being simply kept for exhibition by their owners.

The companionable varieties include the Newfoundland, a most teachable animal, whose merits as a water dog are conspicuously great, and the Chinese Chow Chow, a curiously dispositioned race, which idolizes his master but is loath to receive, and still less to reciprocate, the advances of strangers, and lastly the Poodle The last-mentioned breed is intelligent in the extreme, of a most amiable disposition, and best of companions.

Contained in the category of fancy breeds is the Irish Wolfhound, a gigantic production of modern times, which has been produced by the crossing of the Scottish Deerhound with the German Great Dane. The claims of this breed, therefore, to the prefix 'Irish' would appear to stand upon a very precarious basis, whilst as wolves have long ceased to be included amongst the *feræ naturæ* of this country, his capacity for hunting them can only be taken on credit. The Russian Borzoi, perhaps the most elegant and graceful of all the larger breeds, is, on the contrary, a born wolf hunter, his services as such being largely utilized in his own country, though here they naturally serve him in no stead. The Borzoi, moreover, is not a very brainy dog, and hence he can scarcely be regarded as worthy of inclusion amongst the companionable breeds, his value in England principally depending upon his exhibition points. The St. Bernard, invaluable as his services to suffering humanity have been upon his native Alps, can by no stretch of exaggeration be included in the category of useful breeds, and as the temper of some of these dogs is apt to grow uncertain as their age increases, it is perhaps safer to place the St. Bernard amongst the fancy varieties The day of the Dalmatian as a carriage dog is unfortunately almost a thing of the past, as rarely indeed is this most beautiful and very active carriage dog to be seen in attendance upon the equipages of the wealthy. Consequently he must be included in the list of fancy breeds, and the hope may be expressed that he will long continue to attract the support of those who devote their energies to the breeding of dogs.

The expression Toy Dog explains itself, but it may be added that the development of such elegant and graceful varieties as the King Charles and Blenheim Spaniels and the Pug has been proportionate to the increased attention that has been paid to them. Several foreign varieties of dog have also become popularized in this country of late years, and these will receive attention later on, as will some other varieties from beyond the seas, the merits of which entitle them to consideration in these pages.

Regarding the powers exercised by dogs for discharging different services to mankind, it may be pointed out, without entering too fully into the question of anatomy of the dog, that beyond all doubt much depends upon the structural development of the head. Hounds, pointers, setters, and such breeds as are used for hunting game, with the exception of the Greyhound (which hunts by sight and not by scent), depend a good deal upon the length of their muzzles and size of their nostrils, upon which much of their excellence is supposed to rely. A well-developed broad skull is usually to be regarded as indicative of intelligence, the Bulldog perhaps being an exception to the rule. On the other hand, the narrow-domed skull of such a breed as the Borzoi is not usually associated with much wisdom on the part of its possessor, the base of the Borzoi's skull being decidedly contracted.

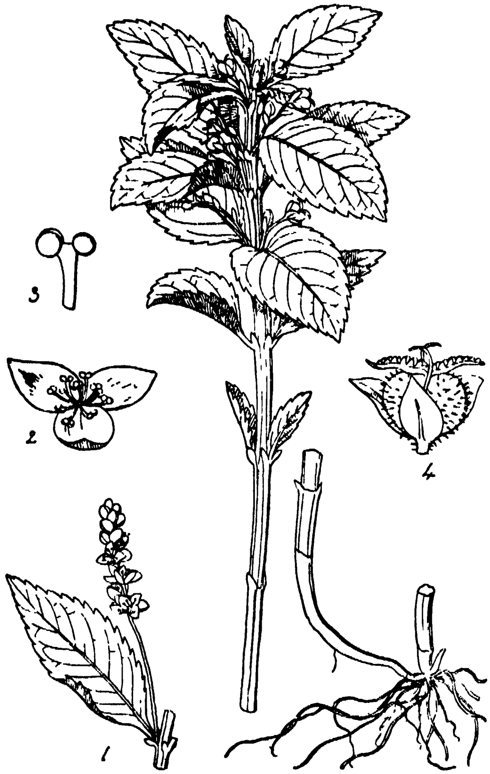
A small eye is usually accompanied by that degree of gameness which is so characteristic of the Terrier family. A light one is not liked, as experience has often proved that it is associated with either a lack of courage or uncertainty of temper. A sunken eye in the case of most breeds is objectionable for the latter reason, but of course there are exceptions, such as the Bloodhound and St Bernard, though it may be added that these breeds cannot invariably be included in the category of benign-dispositioned dogs.

In justice, however, to the natural instincts and abilities of all the varieties of the canine race, it must be understood that these characteristics require to be developed. The vermin-destroying propensities of the Terrier, for instance, though undoubtedly inherent in him, require to be encouraged by a proper course of 'entering' or tuition. A Greyhound which may develop into a valuable dog for coursing purposes may appear perfectly bewildered when he first sees a hare; the steadiest of retrievers in after-life may run riot and mangle his game before his education is completed; and in fact it may be emphatically laid down as an inflexible rule, that to the care and patience bestowed upon their breaking much of the excellence of most working dogs depends. As a matter of course, the greater amount of natural ability there is to work upon, the easier will be the trainer's task, and the more satisfactory the results; hence the importance that is attached to such structural developments as are calculated to produce the natural ability upon which it is desired to work. It is also generally accepted amongst dog-breakers that the descendants of a race that has been trained and used for work are invariably more easily broken and become more valuable animals than those which spring from a race whose capacities have never been developed. See separate arts. on each of the breeds named. [V. S.]

Dog's Mercury (Mercurialis) is the name for a genus of herbaceous plants belonging to the Spurge order (Euphorbiaceæ).

Common Dog's Mercury (*Mercurialis perennis*) is a poisonous woodland perennial hairy herb with extensively creeping underground stems, and simple air stems 8 to 12 in. high. The leaves are opposite, each with dark-green egg-shaped blade, and a pair of outgrowths (stipules) at the base of the leaf-stalk. In this case there are male plants and female plants. In early

spring the flowers appear: on the male the spike of greenish-yellow flowers is conspicuous, but on the female the flowers are not readily noticed, partly because they have no corolla, and partly because the broad leaves hide them. When the female flower is examined, the striking feature is the two-lobed ovary terminated by two distinct



Dog's Mercury (*Mercurialis perennis*) female

1, Male flower 2, Male flower, enlarged. 3, Stamen. 4, Female flower

styles. As cattle reject Dog's Mercury, cases of poisoning from this cause rarely occur. Annual Dog's Mercury (*Mercurialis annua*) sometimes occurs in fields. As a rule this is taller than the former species; it has little or no hair, the air stem usually branches, and male as well as female flowers occur on the same plant.

[A. N. M'A.]

Dog Tick. See Ixodes ricinus.

Dogwood. See Cornus.

Dolerite.—Dolerite is intermediate in grain between gabbro and basalt, and its composition and the characters of the soil formed from it may be understood from the article on Basalt. In some regions dolerite soils are preferred to those on basalt, owing to the readiness with which the more crystalline rock lends itself to disintegration. [G. A. J. C.]

Dolichos is the name for a genus of twining leguminous plants closely allied to the well-known Scarlet Runner (Phaseolus). In the tropical and warmer parts of Asia and Africa, many species are cultivated for their edible legumes and seeds, *e.g.* Horse Grass (*Dolichos uniflorus*) and Lablab (*Dolichos Lablab*). In the warmer parts of Europe, corresponding edible legumes and seeds, known as French Beans and Kidney Beans, are yielded by species of Phaseolus. No species of Dolichos is suitable for growth in Britain, and even in the south of France no species succeeds well. [A. N. M'A.]

Dolomite, a mineral resembling calcite, but formed of equal molecular quantities of calcium carbonate and magnesium carbonate; formula $CaMgC_2O_6$. Even in strong acids dolomite shows very little effervescence until the solvent is heated, thus contrasting greatly with calcite or aragonite. Part of the calcium carbonate in a limestone, even in the mass of a modern coral reef, may become converted by the infiltration of magnesium salts into magnesium carbonate, and *magnesian limestones* and even true dolomite rocks arise. Massive dolomite, as a rock, is usually yellowish, and is often found in patches in the blue-grey Carboniferous limestone of Ireland. 'Dolomitized' limestone is naturally less serviceable than limestone as a source of commercial lime, and the soils on it are said to be less fertile As occurs on limestone, the soils, representing the insoluble residue of the rock, are sometimes red-brown loams or clays, accumulating in pockets and solution hollows. [G. A. J. C.]

Dolphins, a synonym for plant lice or aphides. See Aphides.

Domesticated Animals.—According to Professor Keller, domesticated animals are 'all such as have entered into a lasting partnership with man, are employed by him for definite agricultural or domestic purposes, reproduce freely in this relation, and thus are temporarily or permanently subjected to the influence of artificial selection'. In Britain, the most important domesticated animals are, among mammals, horses and asses, cattle, sheep, goats, and pigs, dogs, cats, and rabbits. These same animals, or nearly allied races, are found all over the world wherever climatic conditions will permit. The Indian humped cattle show, in their drooping ears and other characters, traces of very ancient domestication. For field labour, mercantile, and even military transport, they have spread into many neighbouring countries; but in some regions, such as the Nile Valley, and among the poorer classes generally, the buffalo is more frequently used, because of its more modest requirements and its greater resistance to disease. To the north, on the lower slopes of the Himalayas, and among the mountains of Central Asia, both races give place to the yak. The range of the yak is very restricted, but the animal is of great importance, as it is practically the sole means of transport between Tibet, China, Mongolia, and northern India. It thrives best at a considerable elevation, is extremely surefooted, and can plough its way even through deep snow.

The elephant plays an important part in Eastern countries, but owing to its extreme infertility it is rather a captive than a domesticated animal in the strict sense. But the camel has been bound up with the life of the nomadic

peoples of the deserts and steppes from time immemorial. Of late it has been introduced into Australia, and a great many are now in regular use in West Australia. In South America there are two domesticated races of humpless camels, the llama and the alpaca. The former is valued for its milk and as a pack carrier, the latter for its fine silky hair. The reindeer is the only member of the Deer tribe that has been domesticated. It is impossible to overestimate its importance in cold northern lands, where no other large mammal, except the dog, can exist.

Among birds the chief domesticated forms are those of the poultry yard—fowls, ducks, geese, turkeys, pigeons, &c. The ostrich is of interest, as the only large animal which has been successfully domesticated in quite modern times. Ostrich farming dates from only fifty years back, and the number of birds in Cape Colony is now over 350,000. The Invertebrate Kingdom has supplied us with only two domesticated forms—the hive bee and the silk-moth. The culture of both these forms is of great antiquity. See under individual headings; also Keller's Naturgeschichte der Haustiere, Berlin, 1905. [J. A. T.]

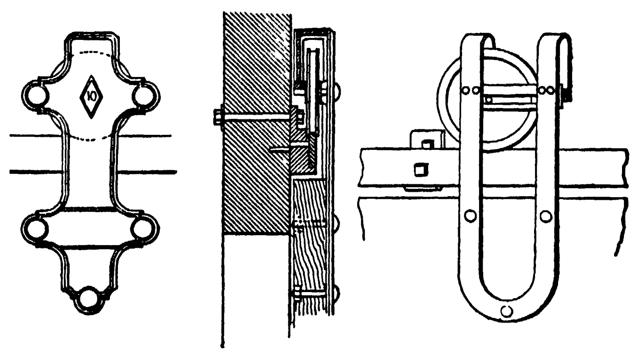
Domestication. See ANIMALS, DOMESTICATION OF.

Domestic Servant. See MASTER AND SERVANT.

Dominique Fowl. — This breed at one time promised to become very popular in America, and a few specimens were imported into Europe. In the older transatlantic poultry books it was given a prominent position, but it has been almost lost in the Plymouth Rock fowl, which, having greater size of body and clearer definition in markings, has met with more favour. As a consequence, very few Dominiques remain. It is stated that the breed has been known for more than a hundred years, but we have been unable to trace any reliable records as to its origin. In shape it is a tall upright bird, with a deep body standing upon strong full-boned legs, which are yellow in colour, as is the flesh and skin, a feature of American races referred to elsewhere. The tail is short, an evidence of descent from some Asiatic breed. The comb is rose, and of moderate size. The plumage is what is known as barred; that is, the ground colour of each feather is greyish-white, crossed with bars, varying in width, of blue-black. Adult males weigh about 8 lb. The hens are good layers of tinted-shelled eggs, and excellent sitters and mothers. In flesh qualities the breed is fair, from a European standpoint. Hardy in constitution is a great recommendation in any breed, and this is characteristic of the Dominique. [E. B.]

Donaldson, James, the name of two Scottish writers on agriculture, the earlier of whom wrote a book entitled Husbandry Anatomized: or an Enquiry into the Present Manner of Tilling and Manuring the Ground in Scotland, published in 1697.—The other JAMES DONALDSON, a land surveyor and steward for some large estates in Scotland, was one of the most useful writers on the agriculture of his native country. Among his published works written in the end of the 18th century may be mentioned the following: General View of the Agriculture of the County of Nairn; General View of the Agriculture of Elgin and Moray; with similar works on the agriculture of the counties of Perth, Banff, Mearns, and Northampton. He was also the author of a general work on agriculture: Modern Agriculture, or the Present State of Husbandry in Great Britain (4 vols., 1795–6). [J. B.]

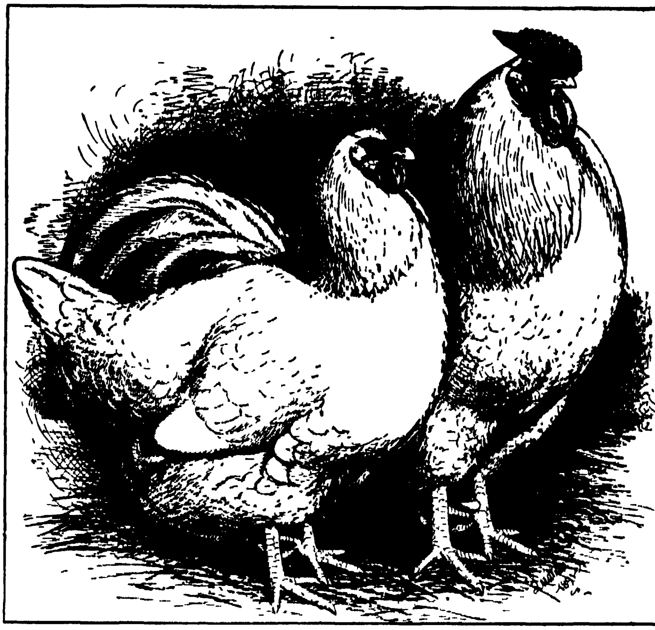
Doors.—Whenever it is practicable to hang the doors of farm buildings on rollers, this is a preferable method to hinging them at the side. The hinged door is usually the sport of every gust of wind. Except when latched, it is never still while the wind blows. Stock going out and in are apt to be injured by it slamming against them; and from the same cause it interferes with the 'hands', both when they are carrying in fodder and wheeling out litter. And besides being a nuisance in these respects, the hinged door, when thus left to circumstances, is sore on itself. Especially is this the case with regard to the larger doors at the steading—that of the straw barn, for instance. A heavy door such as we generally find necessary at this point gets badly shaken when it is allowed to go full bang against the wall at the side of the doorway. The wall suffers too; at any rate the rybates or scuntions of the doorway get loosened. The hanging door with pulleys running on an overhead rail has none of these faults. It will stay at any point we choose, leaving an opening an inch or a foot wide, or keeping the whole doorway clear, just as we wish. Wind has no effect on it. It is easier to work and lasts longer than the hinged door. It is a little dearer to begin with, perhaps. The rail and pulleys cost more than hinges, and the door itself requires to be a little heavier. Stout boards, grooved and tongued, secured to three strong rails or cross boards behind, suffice for the hinged door of the smaller openings at the steading, but a framed door is essential where rail and pulleys are in question. The latter plan, however, saves stiles and lintel, which are requisite parts in connection with the hinged door; and the necessary stops for attachment to these.



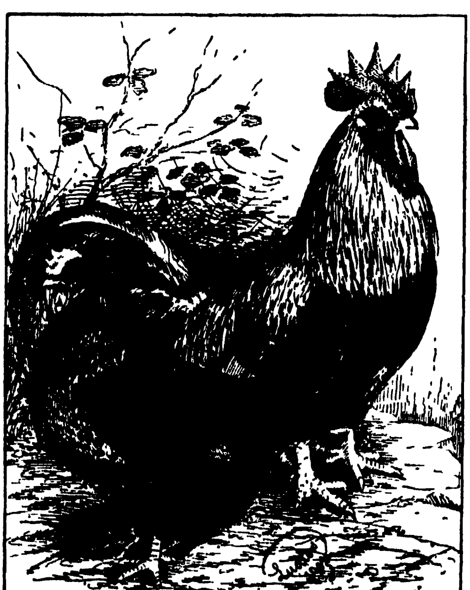
Rollers for Hanging Doors.

There are fewer parts about the sliding door, and it is easier on itself, which are strong recommendations in its favour. The outer doors of farm buildings are best of red pine. This stands weather better than white pine. The latter, if of good quality and duly painted, would do well enough, but paint is too often denied them. White pine answers for the inner doors. Whatever kind of wood is used it ought to be of good quality, and what is even of greater import, it must be thoroughly seasoned to begin with. It is false economy to use clumsy (because cheap) rollers for the hanging door. There are many suitable contrivances on the market at a reasonable figure. The annexed figures represent examples of such. [R. H.]

Dorking Fowl.—It has been stated that the Dorking is the Shorthorn of domestic poultry, but it can lay claim to a length of ancestry far beyond that famous breed of cattle. Nearly two thousand years ago a race of fowls was kept in Italy which would appear to have been the progenitor alike of the English Dorking and the French *poule commune*, which are practically one and the same. In the absence of direct evidence to the contrary, it may be assumed that the breed was introduced both into Gaul and Britain when those countries were subject to the Roman power. For centuries it has been bred in the south-eastern counties of England—obtaining its modern name from Dorking in Surrey—on the Cumberland and Westmorland hills, and in Scotland. With the exception of the Fighting Game, it is the oldest European breed, and no other race has exerted the same influence, more especially in relation to its meat qualities, not only when bred pure, but in connection with the production of other breeds. In spite of changes resultant from extremes in breeding, it has retained and maintained those essential qualities which for centuries have given it a leading position.



White Dorkings



Dark Dorkings.

The appearance presented by this breed is that of a large massive bird, built on broad lines throughout, in that it is broad, wide, and deep in body, and by the uniformity of outline in back and breast it forms an oblong square, with large head and thick but short neck, and short light-boned legs, which are pure white in colour, as are the toe nails. The thighs are stout but not heavy, and the flesh is chiefly upon the sternum or breast, which fact is proved by the large and long wings. One feature, known from the Roman period, is that the birds have a supernumerary toe, making five in all, of no value in itself save as a sign of purity of race. The persistency of this additional digit indicates that it is no merely modern addition. Of Dorkings there are four colours, namely Dark or Coloured, Silver-grey, White, and Cuckoo. At one time there was a Red Dorking, but few are to be seen, and it has evidently been merged in the Red Sussex (see Sussex Fowl). The Cuckoo

variety is almost extinct, and Whites are kept chiefly as exhibition stock. The Darks are rather the larger, but Silver-greys are lighter in bone and carry as much meat. All have single combs except the Whites, which carry a rose comb. Adult male birds weigh 9 to 12 lb., and females 7 to 10 lb

As already stated, the Dorkings are essentially meat producers, and they have a good capacity for fattening, yielding a large quantity of flesh which is soft and fine in texture. The hens are early layers of large white eggs, but are not very prolific. They make excellent sitters and mothers. The chickens grow rapidly, and under a proper system of rearing and feeding, are ready for market in eleven to twelve weeks. But they require favourable conditions. An undulating country, with light porous soil, is needed, and where there is plenty of natural food they are excellent foragers. Heavy clay or cold damp land is fatal to them, and under those conditions it would be useless attempting to keep Dorkings. [E. B.]

Dormouse, a general name for the Myoxidæ, a family of arboreal rodents, squirrel-like

Dormouse

in appearance, but structurally allied more closely to mice They are distinguished from most other rodents by the possession of a single pair of premolars in each jaw, and by the rooted cheek-teeth with transverse folds of enamel, and from all others by the absence of a cæcum. The family is confined to the Old World, but is not represented south of the Himalayas in Asia. The Common Dormouse (*Muscardinus avellanarius*) is the only British member of the family. It is about 5½ in. in length, including the bushy tail, is of a tawny-red colour on the upper surface, paler underneath, with a white patch on the throat. The eyes are black and bright, the ears rounded; the toes four in front, five behind, are adapted for grasping. Its food consists mainly of fruit, nuts, and seeds, but it also eats insects and grubs of all kinds. It is found throughout the greater part of southern and central England, but is not known to occur in Scotland or Ireland. The period of hibernation is unusually long, often six months, but sleep is not profound, for on mild days the Dormouse wakes up to feed from its store of nuts. The young, usually four in number, are born in spring.

The Dormouse is not sufficiently abundant in any part of Britain to be of much importance, but some of the allied species, such as the Fat Dormouse and the Garden Dormouse, which are common in other European countries, do great havoc in orchards and gardens, and are therefore killed in great numbers. [J. A. T.]

Doronicum, a genus of herbaceous perennials, some of which have showy yellow daisy-like flowers, and are therefore cultivated in gardens. They are good-natured plants, growing vigorously even in poor soil. The Leopard's Bane (*D. plantagineum*) grows wild in England, usually in plantations, and flowers from May to July. It had the reputation of being so poisonous as to kill panthers It is a robust plant, with large roughish leaves and conspicuous flower-heads. Other species that are grown in gardens are *D. austriacum*, *D. caucasicum*, and *D. Columnæ*. The most popular of all is *D. excelsum*, which flowers early in the year, and is largely employed for spring bedding. [W. W.]

Dorset Down Sheep.—The origin of the Dorset Down sheep may be traced from a date about eighty years ago, when the late Mr. Thomas Homer Saunders, of Watercombe, near Dorchester, commenced his work of improving the class of Down sheep then generally bred in the county.

He found the native race of sheep 'kindly', but deficient in size, and he therefore selected the largest ewes he could find, which in many cases were descended from the flock of Mr. Ellman, of Sussex (who in his day did much to improve the Southdown or Sussex breed), and crossed them with rams of a still larger size—obtained wherever he could find any suitable to his purpose,—and so by judicious crossing, and keeping a careful pedigree to help him, he in time created a type of sheep that ultimately became known as the 'Watercombe Breed of Improved Hampshire Downs'. With animals of this breed he and his son, Mr. Thomas Chapman Saunders, gave a certain stamp and character to the Down breed of the county, and they were remarkably successful in showyard competitions in the short-woolled classes of their day.

Coeval with the work of Mr. Saunders was that of Mr. Humfrey, of Chaddleworth, near Newbury. He selected some of the large coarse Berkshire, Hampshire, or Wiltshire ewes and crossed them with pure Southdown rams from the celebrated flock of Mr. Jonas Webb, and after many years of careful breeding and selection he produced a similar class of sheep to Mr. Saunders's, which were styled 'West Country Downs'; and his exhibits of these sheep at the Royal shows of Chester (1858) and Warwick (1859) carried off almost all the prizes in their respective classes.

The sheep bred by Mr. Thomas Homer Saunders and Mr. Humfrey were largely introduced into the Down flocks of Dorset, and also into many of the flocks of Hampshire and Wiltshire, and in return the Dorsetshire breeders have to a large extent resorted to the leading flocks of these counties for their requisite changes of

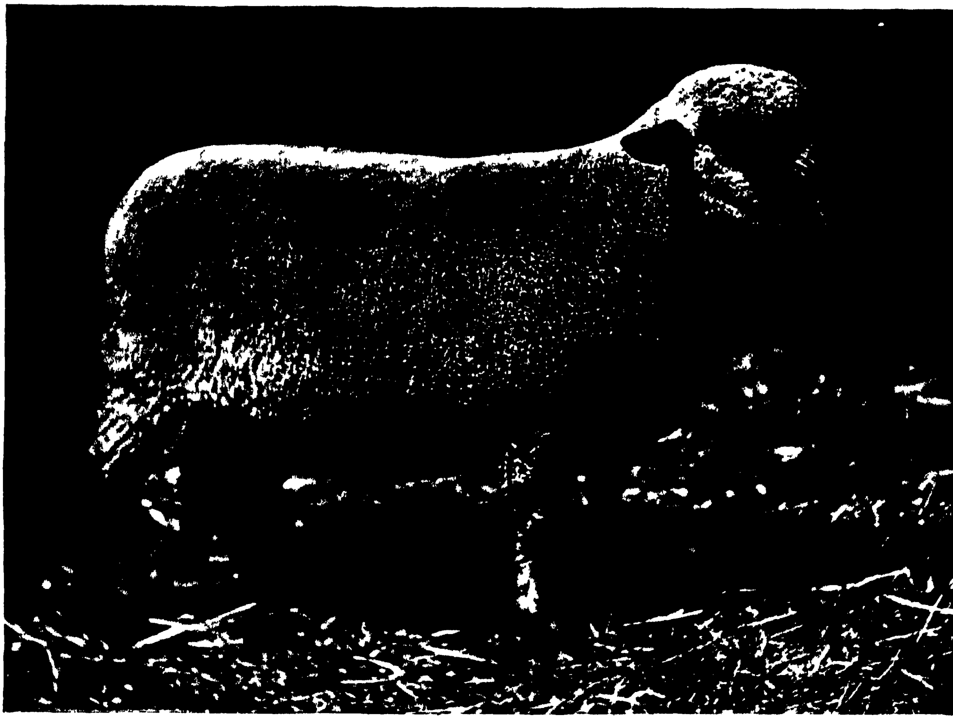


Photo G H Parsons

DORSET DOWN RAM

1ST AT BATH AND WEST OF ENGLAND SHOW, 1908

(05)

Photo G H Parsons

DORSET SHEARLING RAM

WINNER OF 1ST PRIZE AT R A S.E SHOW, 1908

blood, with the result that the Dorset Down breed now registered, although of finer bone and often of lighter colour, is closely related to and possesses the principal features of the Hampshire Down type, modified by local conditions.

A good type of Dorset Down should be free from all coarseness, the chief points being a rather long, full, clean face and under jaw, with a bold bright eye and full muzzle; the ears should be fairly long, thin, pointed, whole-coloured, and carried well above the level of the eyes; the neck strong and well set on. The animal should be rather fine boned, and covered with a close fine fleece going well down to the hocks and knees, round the cheeks, between the ears and on the forehead; but wool under the eyes, or across the bridge of the nose, on the ears, or below the hocks and knees, is to be avoided. It is desirable that the face, ears, and legs should be of a brown colour. The Dorset Down should embody the good points common to all breeds of sheep, but should be especially good through the heart and behind the shoulder; it should also have a well-let-down and rounded leg, and, whilst not standing too short, there should be no tendency to legginess.

The breed is noted for its fecundity, and the lambs are very suitable either for early fattening or for later feeding. These sheep are capable of producing either sucking lamb from ten to twelve weeks old of the primest quality from 40 to 48 lb. in weight, or at from eight to nine months old a well-finished carcass weighing from 66 to 72 lb. of the very best quality of fleshy mutton, thus meeting the preponderating demand of the dead-meat market for joints of more quality and less waste. The Dorset Downs are of a hardy and robust constitution, and they thrive well either in wide open grazings or when confined within hurdles.

The principal annual sales of draft ewes and lambs are those held at Dorchester and Blandford during the months of July, August, and September, when large numbers are purchased for Sussex, Surrey, Hants, Wilts, Somerset, and other parts of the kingdom. Classes for the breed have now been established at the annual shows of the Bath and West and Southern Counties Society, and the Smithfield Club in London. [E. B. D.]

Dorset Horn Sheep.—The Dorset Horn breed of sheep claims to be regarded as amongst the first half-dozen of the oldest and purest breeds in the whole of the British Islands. The possession of horns, be they desirable or not, indicates sheep whose natural home is on the moors and mountains, and though there are differences of opinion as to the usefulness of horns on sheep, as to the picturesque adornment contributed by horns no need exists for disagreement. The question is almost wholly one of fancy rather than of fact, especially where the sheep are kept within boundaries, as in England. But in the great ranching areas of western North America, where they are free to roam at will over extensive tracts of broken country, with boundary fences many miles in circuit, and where coyotes and other carnivorous and predatory animals have access to them, the possession of horns is found to be a means of protection to sheep of the Dorset Horn breed. American breeders of these sheep advertise them as 'dog-proof', and this is very properly regarded as a great advantage in wild countries, where sheep-worrying by dogs is apt to occur.

The high antiquity of the breed is unquestionable, but its present identity with the original type is subject to modifications effected by crossing with polled Somersets—an old-world white-faced breed now practically extinct—and later on with Leicesters, from which are derived the paler faces of present-day Dorsets. But this old-time crossing was not systematic, and never general—and the old blood of the breed predominates now in the type. It is said that Devonshire Knot rams were formerly used for crossing, to some extent not now ascertainable; but all breeders of repute, believing the old breed to be worth preserving 'pure and undefiled', and also to be susceptible of due improvement within its own borders, went on lines of selection rather than of crossing with alien blood. And there was ample room within the breed for selection, without incurring the risk of too close inbreeding.

The differences between improved Dorsets of to-day may still be realized to some extent by comparing modern flocks that have been improved, with certain others that have been kept practically unimproved. The point herewith advanced is the susceptibility of the breed to improvement from within—independently of alien blood,—and this faculty is now actually realized and realizable to a degree that is at once satisfactory and encouraging to all concerned. The unimproved sheep in pre-Reformation times were small, with light fore quarters, dark-brown noses, and horns curving upward, and then downward and forward. Youatt, a writer of good repute in the first half of the 19th century, says the Dorsets of his day were entirely white in colour. These were sheep already to some extent improved, and the description—no doubt correct at the time—is equally applicable now.

Among the early improvers of the breed were Mr. Seymour, of Bradpole (who is said to have had the best flock in the county of Somerset in the first quarter of the 19th century); Paull, of Burstock; Pope and Pitfield, of Symondsbury; the Davys, of Horn Park and Netherbury; Chick, of Eggardon; Way, of Bradpole, and others. It is to be noted that improvement of the breed has been contemporary with that of other breeds during a period wellnigh touching a hundred years. It is perhaps more active now, and more general, than in any decade of last century. And as for the reputation of the breed in various parts of the world,—that is certainly greater than it has ever been aforetime.

In the United States of America and in Australia, associations have been formed to further the interests of the breed. Its popularity in these countries is no doubt largely due to the fact that it is one of the most prolific of sheep breeds. This fact is commented on in an essay printed in the first volume of the Flock Book (1892) by Mr. J. T. Ensor. He says: 'The property of

the Dorset Horn sheep which remarkably distinguishes them is the fecundity of the females, and their readiness to receive the male at an early season. They produce from 130 to 180 per cent of lambs, and have been known, like the sheep of some warmer countries, to produce twice in the year.'

In former days these sheep were slow in coming to maturity and in fattening. To describe them as wiry and weedy may be uncomplimentary, but not incorrect. It was a condition shared at the time by various other breeds which have since been similarly improved. It may be said, however, that certain modern breeds—to wit, Hampshires, Oxfords, Shropshires — built up with the generous aid supplied by alien blood, have become susceptible of earlier and greater development than has been the case with most breeds native to hills and moorlands, even when the latter—being free from alien blood—have been taken in hand on soils of better quality, in situations less bleak and exacting. Dorset Horns, however, more or less indebted as most of them have been to infusions of alien blood, are found to respond satisfactorily to improved food and better environment.

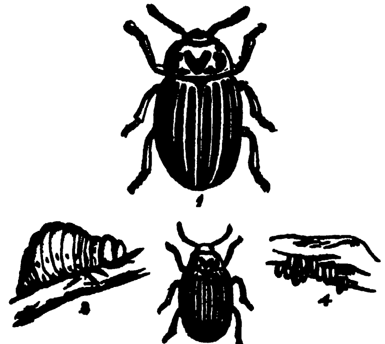
Breeders of improved Dorset Horns for many years nave regarded their flocks with a feeling of pride which is indispensable from continued improvement. These sheep have been, and are still being, bred on a range of soils including Chalk, Greensand, and the greatly varying Oolitic soils, on some of which the grass is succulent and almost evergreen, whilst on others —mostly found on the uplands—pastures can only be said to provide 'short commons' of grass whose quality is greatly inferior to that of the more varied grasses of the lowlands. To each and all of these disparate soils and pastures the Dorset Horns have constantly shown themselves adaptable. This is also the case in various countries to which these sheep have been exported—United States of America, Canada, Australia, New Zealand, and elsewhere, on soils and in climates which greatly extend the range of natural conditions to which they were accustomed in their native Somerset.

The first volume of the Dorset Horn Flock Book for England was published in 1892, registering 277 rams, and giving interesting and useful historical and statistical particulars concerning nigh upon 140 leading flocks, and the names of more than 160 members of the Association.

The headquarters of the Association are in Dorchester. [J. P. S.]

Dorset Pigs.—Some thirty to forty years ago one of the sights of the Smithfield Club's show held in London was the exhibit of those slate-coloured pigs which were sent up from the county of Dorset. These pigs had a wonderful aptitude to lay on flesh, or, as it would now be more appropriately termed, fat. Although they were considered to be of the smaller type of hog, yet the weights to which these obese animals were forced ere they arrived at the then limit of eighteen months were really wonderful; in fact, so forced were these roly-poly pigs that life must have been a burden. To prevent accidents from suffocation the pigs were supplied with pillows made from round pieces of wood. These were placed by the pigmen under the snouts of the reclining beauties; whilst the effort to walk out of the pens to be examined by the judges was frequently so great that the attempt was often abandoned. The feeding of these pigs must have been as expensive as it was successful, from the crammer's point of view. Dairy by-products were said to enter largely into their diet, but probably a good deal of the large quantity of milk which they consumed had been innocent of the attention of the dairymaid with her skimmer. Then treacle or sugar was not unknown to them, as it would have been impossible to have packed on to the carcasses of the pigs so vast an amount of soft blubbery fat without the assistance of saccharine in some form or other. Notwithstanding all this advertising and stuffing, or mayhap because of the latter, the Dorset pigs have so completely changed their character that the long-snouted, thick-necked, short-bodied fine-boned lump of fat meat of low quality has become a thing of the past. The local pigs were crossed with the Berkshire and the west country Large Black, and subsequently with the Large White Yorkshire, so that the present type of pig kept in the county of Dorset converts the dairy by-products into pork which lends itself far better to the manufacture of that bacon for which the adjoining county of Wiltshire is famous all the world over. [S. S.]

Doryphora decemlineata (the Colorado Beetle) is extremely injurious to the potato



1, 2, Colorado Beetle (*Doryphora decemlineata*), magnified and nat. size. 3, Caterpillar. 4, Eggs.

crop in America, and its occasional introduction into England has often given rise to anxiety lest it should establish itself in this country. In 1877 notification of its appearance was made compulsory, and it was rendered a fineable offence to be in possession of the insect alive in any stage. It has not so far, however, obtained any foothold in the British Isles, probably finding the climate unsuitable. The beetles are orange-coloured, about ½ in. long, with five longitudinal black stripes on either wing cover, hence the specific term *decemlineata*. [C. W.]

Dot Moth. See MAMESTRA PERSICARIÆ.

Double Flowers.—Doubling in the sense in which it is applied to flowers is due to a change of structure either in the stamens and

pistils, which are petal-like, or to the development of a larger number of petals where normally there are none. The double Rose, for instance, is due to the stamens having become petalloid, but the double Chrysanthemum is due to a multiplication in the number of petaloid florets which form the head, and the double Dahlia to the whole of the disk florets becoming like those which form the ray. The cause of this change is no doubt due to excess of food. It is of common occurrence among cultivated races of plants, and it has been turned to great account by breeders. In the case of the Rose and the Carnation, doubling is a decided improvement in an æsthetic sense, but in most instances it is a disfigurement. [W. W.]

Douglas Fir, also called **Oregon Pine** (*Pseudotsuga Douglasii*), is one of the best, quickest growing, and most profitable and beautiful of all the trees that have been introduced into Britain from North America. It belongs to the Abietineæ tribe of the Coniferæ (see CONIFERS), and is far more closely related to the Silver Fir, Spruce, and Hemlock genera than to the Pine, Larch, and Cedar. Like the former, it has thin broad cone-scales, which become thinner at the edges, and is an evergreen tree with single leaves persisting for several years, and with seeds ripening within one year. Like the Silver Fir, its closest relative (despite the generic name Pseudotsuga), it differs very perceptibly from Spruce and Hemlock by having smooth twigs without any prominent leaf-scars, and the bracts of the female flowering-spike considerably longer than the seed-scale; while it is distinguishable from the Silver Fir in having (1) petiolated leaves that are longer and narrower than the comparatively shorter and broader sessile leaves of the latter, and in having the two white grooves less plainly marked on the under surface; (2) leaf-scars transversely oval, and not circular; (3) cones pendulous when ripe and with scales persisting to the spindle after the seed is shed, in place of erect cones and deciduous scales; and (4) large pockets of aromatic resin collected in pustular sacks below the outer skin of the bark along its stem. The longer and softer foliage of the Douglas Fir can usually be easily distinguished by its comparative length and softness, and especially by its delicious aroma differing from that of the foliage of any other tree. It is indigenous to the Rocky Mountains and Vancouver Island, where it forms large forests over about 50,000 sq. miles, between 43° and 52° north latitude. Its finest growth is in Oregon, where it attains up to 300 ft. high and 27 ft. in girth; and in the Sierra Nevada it ascends to 8000 ft. The explorer Menzies first discovered it about the end of the 18th century, but its seed was first sent to Britain by Douglas in 1828 (who was trained as a forester at Scone, where two trees stand raised from the first seed then sent home, and whose monument stands in Scone churchyard). As regards rapidity of growth and timber-production it is only equalled by the Menzies Spruce. In 1903 the two largest recorded specimens in Britain were 127 ft. high and 11½ ft. in girth (73 years, Bucks), and 103 ft. high and 9 ft. in girth (58 years, Perth); while at Shelton Abbey (Wicklow) a fine specimen girthed 81 in. at 27 years of age, or an average of 3 in. a year. But the biggest of all is one planted on the Lynedoch estate (Scone) in 1834, which in January, 1908, girthed 13 ft. 9 in. at 5 ft. up, has a bole 60 ft. long and 7 ft. 5 in. at top end, where it forks into two branches 48 and 40 ft. long, and contains over 463 cu. ft. of timber. In point of general utility the Douglas Fir is the most important tree introduced into Britain in the 19th century. Only one introduced species, the Larch, surpasses it in economic value; for the reddish heartwood of the Douglas Fir, known locally in America as Columbia Redwood or Red Pine, ranks in durability and market value about halfway between Larch and Scots Pine. In America it is largely used for ship- and house-building, carpentry, furniture, and general purposes. Nor is it of less value for ornamental purposes, because its habit of growth in the open is extremely ornamental, its branches being thickly clothed right down to the ground with dense foliage persisting for 5 to 7 years. In respect to foliage, however, there are two distinct natural varieties of Douglas Fir (besides several others artificially propagated), which exhibit differences that might perhaps well entitle them to be considered two different species. The Columbian or Pacific coast variety has longer and darker foliage and produces more and better timber than the glaucous and more thinly foliaged Colorado variety, which, however, is the hardier in withstanding severe frost. But both kinds are fairly hardy in Britain, except in very damp and low-lying spots. On good soil, young poles in plantations of about ten years old can make shoots of 54 to 57 in., whereas the best Larch in the same plantations make from 48 to 53 in. Being a thickly foliaged tree it can bear side shade, though it does not stand drip from above. It soon tends to spread laterally and to run into strong lower branches; hence to grow clean boles it should be planted and kept fairly close for so very quick-growing a tree—say about 4½ to 5 ft. apart when planting, or not exceeding 6 ft. where young thinnings are not disposable. During gales it is apt to lose its leader, though a side-shoot soon replaces this. Neither the yield per acre nor the true technical and market value of fully mature British-grown timber is yet known. But the most celebrated Douglas Fir plantation in the United Kingdom, the small 8-acre plot formed at Taymount (Scone, Perth) in 1860 at 12 by 12 ft., and filled with Larch at 6 by 6 (302 Douglas Fir and 908 Larch per acre), was in 1888 (after all the Larch had been overgrown and thinned out, and over one-fourth of the Douglas Fir had also been removed) estimated to contain 3738 cu. ft., or an average of 117 cu. ft. a year. In January, 1908, it contained 1536 trees cubing 51,456 ft. of timber, or 192 trees and 6432 cu. ft. per ac., the two largest trees being respectively 93 ft. high and cubing 117 ft., and 99 ft. high and cubing 105 ft. of timber. The Douglas Fir bears good seed freely from about 25 years of age onwards, and is easily cultivated by sowing the seeds in drills on seed-beds and covering them lightly with the mould,

till seedlings can be transplanted into the nursery lines, and are ready for planting out as one- or two-year transplants. It thrives best on a deep and fresh sandy or loamy soil, and even on stiffer land if the natural drainage be good; but it does not do so well on a limy soil, and is altogether unsuitable for growing on chalk. In mixed plantations the only other tree likely to hold its own with it in rate of growth is the Menzies Spruce, and sometimes also the Weymouth Pine. If mixed with Larch it either suppresses this, or else, if that be given a sufficient advantage in height at first, gets its leader badly whipped and damaged. Already it has been attacked in Britain by insects and fungi, two of the latter being *Botrytis cinerea* and *Phoma pithya*, which may perhaps become serious diseases if large pure plantations be made. See next art. [J. N.]

Douglas Fir.—Parasitic Fungi.—A brownish-grey mould (*Botrytis*) appears on young shoots, which quickly flag and wither. Diseased trees should be removed and burned; if still in the nursery, frequent spraying with Bordeaux mixture will check it (see Gardener's Chronicle, Feb. 1900, with figures). Another fungus (*Phoma pithya*) causes a girdling of young stems. Young trees may also be attacked by ring-scale and root-rot. See PINE.—PARASITIC FUNGI. [W. G. S.]

Douglas Fir Seed Pest. See MEGASTRINUS.

Dove.—The name 'dove' is usually applied to the smaller members of the group of pigeons (Columbæ). There are four species of wild dove known in Great Britain. Of these by far the commonest is the Ringdove or Wood Pigeon, which has increased so greatly in numbers in recent years. It is easily recognized by the white patches on each side of the neck, suggestive of a ring, and by the white marks on the wings, which are very conspicuous in flight. The second species is the Stockdove, distinguishable from the Wood Pigeon by the absence of the white patches on the wings and neck. The third species is the Rockdove, from which are derived all the innumerable varieties of domesticated pigeon. In a truly wild state the bird is not common in the British Isles. It is easily distinguished from the Stockdove by its white rump. The fourth species of British dove is the Turtledove, which, however, is only a summer visitor, and rarely reaches Scotland. It is smaller than the other doves, and can be at once recognized by its well-known *coo*. [H. S. R. E.]

Down, Downland, Wold.—These terms may merely express open, undulating, and uncultivated land; but in a stricter sense, districts of a 'common' character, which may be partially cultivated. They may also refer to the past, as when cultivated land is still named 'down', having been broken up comparatively recently. The term 'down' is usually applied to the escarpments and tablelands of the Upper Chalk formation, which only occur in the southern and eastern counties, although the names *North Downs* and *South Downs* are given to two definite ranges of hills as a geographical term. Following the Chalk formation, the downs take [illegible] each county in succession, as for example the Kentish, Sussex, Hampshire, Wiltshire, Dorset, Berks, Oxford, and Bucks Downs. The same holds good in Essex, Suffolk, and Norfolk, where they are sometimes designated *heaths*. There are no fewer than seventeen counties in which the Chalk formation occurs. In Yorkshire and Lincolnshire they are termed *wolds*. The centre of the Down districts is Salisbury Plain, from which, with the exception of the Lincolnshire and Yorkshire wolds, all the downs ramify. From this great central plateau of the Upper Chalk, branches extend to the east, west, south, and north, which may be traced as follows:—

1. The Surrey, Sussex, and Kent downs, ending at Dover and Beachy Head.
2. The Wiltshire and Dorset downs, extending to Weymouth.
3. The Hampshire and Isle of Wight downs.
4. The extension through Berks, Bucks, Herts, Beds, Cambridgeshire, to Norfolk, Suffolk, and Essex, as above indicated.

There is a general resemblance in all these districts, and a similarity in the agriculture followed. The proportion under arable cultivation varies principally with their altitude and slope, but it is always interspersed with open and uncultivated down. The agricultural features may be summarized as follows: Position high-lying and exposed, free from timber, and carrying a sweet and short herbage; intersected by valleys of denudation, watered by streams flanked in many cases with water meadows, and well timbered. The soil is thin, interspersed with flint stones, often dark-coloured, but sometimes white; easy working, inclined to be poor but grateful, and capable of producing heavy crops under liberal sheep management; low rented, and in large holdings often of 1000 acres; ideal sheep land; well adapted for growing clover, sainfoin, vetches, and other leguminous plants; good turnip and swede land, producing in even a natural condition wheat crops of 28 bus. per acre. The fields are large, and are in many cases undivided by fences. The situation is particularly healthy and breezy, and there is seldom much difficulty in harvesting either hay or corn crops. They suffer less from drought than their light nature would suggest. On the other hand, they are easily 'run out', and require to be kept up in condition by the maintenance of large flocks, and the free use of artificial foods. The wolds of Yorkshire extend inland from Flamborough Head, and form a definite high-lying tract which is indeed only separated from the Lincolnshire wolds by the river Humber. In Lincolnshire they form a section of the county from north to south, overlooking the marshland which lies between them and the sea, and they terminate under the flat alluvial soils north of the Wash. The formation appears once more south of the Wash, and is then continued as a part of the Chalk formation already outlined. [J. Wr.]

Down Breeds of Sheep.—The Downs (see preceding article) have always supported breeds of sheep which possess many characters in common. They may be described as brown-

faced and brown-shanked, hornless, short-woolled, of moderate size, and active in their habits. Their mutton is of superior quality, being fine in the grain and rich in colour. They are also well adapted for folding, and feed in mobs when at liberty. Before the improvement of the Sussex or Southdown, every Chalk county boasted its own breed of Down sheep, which naturally took its name from its locality. For example, there were Kentish, Essex, Sussex, or Hampshire Down sheep, and the same was equally true in the remaining counties in which chalk hills form a feature. All these breeds (which were probably originally allied) were crossed repeatedly with Southdowns, until most of them have disappeared as distinct breeds. The best-known survivors of the many Down sheep of the 18th century are the South or Sussex Down, the Hampshire Down, and the Suffolk Down. The Oxfordshire Down is a modern breed of composite origin which was unknown previously to 1840. Another exception is the Dorset Horn or Down, which is a whitefaced and horned race occupying the chalk hills of its native county. The contrast between Down sheep and the long-woolled races is very marked as regards colour, fleece, weight, quality of flesh, and adaptability to particular soils. Down sheep alter in their character when bred on richer and lower soils, and in order to maintain their peculiarities, sires are imported from their native downs—notably in the case of Southdown sheep. Being 'patient' under folding, they can be massed in large numbers upon a limited area, or kept more thickly upon the ground than long-woolled sheep. They are highly esteemed and universally used for crossing with the heavier breeds, and the progeny not only combine the good properties of the two parent forms, but always exhibit the valuable attribute of early maturity in a special degree. [J. WR.]

Draff. See Distillers' Grains.

Drafting (of Stock).—In order to keep up a regular stock of ewes or dairy cows it is essential that a certain number of the older animals be drafted or removed every year. To take the places of these and keep the head of stock at the same figure a number of young animals require to be brought in. The number of animals brought in each year must be sufficient to allow for all losses during the years they form part of the regular stock.

In the case of ewes, and hill ewes especially, the state of the pasture has much to do with the ages at which they are drafted, and on certain pastures they must be drafted sooner than on others. As a general rule, drafting takes place shortly after the fourth crop of lambs has been weaned, that is when the ewes are at the age of five and a half years. Although this is a common custom there are many exceptions, and in some places the ewes are drafted a year earlier just when they are at their very best, the reason being that they realize a much larger price than would be the case at a later period. In other places, again, the ewes are kept till after the fifth or even the sixth crop of lambs, if they are still correct in their mouths. This latter method is commonly practised on large farms that are partly 'hill' and partly 'arable'. The ewes form part of the regular hill flock till after the fourth crop of lambs; they are then brought down to the low ground for one or two years, and rams of one of the larger breeds, *e.g.* Border Leicester, Yorkshire, Oxford, or Suffolk, put to them. After that, instead of being sold as 'cast ewes', they are fed off on part of the 'green crop', receiving in addition a fair allowance of concentrated feedingstuffs, such as a mixture of oats, dried grains, and decorticated cotton cake.

In the sale of draft hill ewes it is usual to guarantee them as correct in their mouths and uncrossed whenever that is so. Ewes that have been once crossed even, *i.e.* 'milled ewes', do not realize the same price, and if they are not correct in their mouths the price falls still further. Drafting does not take place, however, based entirely on the age and mouth of the ewes, for there are various other things to be taken into consideration, of which the following may be mentioned.

1. Condition of the Ewes.—Ewes that are very thin, even though they have only had one or two crops of lambs, are not likely to do well during the following winter unless specially treated, and all such are better disposed of now irrespective of age.

2. Infertility.—Ewes that have proved infertile, or that have aborted, should be put away also; yeld gimmers, however, are usually allowed to run for another year.

3. Udder.—In many cases, especially among lowland flocks of ewes where the animals give a larger flow of milk, the udders sometimes go wrong after weaning, unless the ewes are occasionally milked by the shepherd. This precaution is not always taken, and very often some of the best and milkiest of the ewes go wrong, and require to be disposed of. Some ewes, again, are very poor milkers, and hardly able to support one lamb Such animals should not be kept, as they seldom improve.

4. Disease.—Ewes that show any trace of disease, such as liver rot, sturdy or gid, &c., should on no account be kept.

With regard to the drafting of dairy cows, it may be said that the system has undergone considerable change since the introduction of 'milk records'. The method once commonly practised was something akin to that still employed in the drafting of ewes, only the age and general condition of the animals being taken into consideration. It was too often thought that if a cow gave a comparatively small yield of milk, that milk was just so much the richer, and what was lacking in quantity would be partly made up for in quality. Fortunately this belief no longer exists, and consequently there is now no room in our byres for the 'poor' milkers, and they have to go. Of course it is quite possible that a young cow may milk somewhat poorly during her first year and improve very considerably in her second, so it is advisable when applying the 'milk-record test' to young animals to continue it for two years. This precaution is not quite so necessary when dealing with older animals.

Cows are usually drafted between the ages of nine and thirteen years, but from what has already been said it may be concluded that 'milk yield' is the chief thing to be considered, and the age of the cow is of secondary importance. A very good milking cow would be kept a few years longer, whereas a poor milker might be disposed of a year or so earlier.

Of course the health and temper of the animal, the udder and the size of the teats have always to be taken into consideration, and are not items that can be lightly passed over. Nevertheless, if a cow gives a large yield of fairly rich milk, then that seems to act as a kind of cloak, and is capable of covering a multitude of sins.

[W. G. R. P.]

Drainage.—Such a large proportion of the land surface is so deeply and adequately drained by natural agencies that special consideration is required to make clear why it may be necessary in special cases to resort to artificial drainage, or how it may be best accomplished. In the natural processes of rock weathering constantly and universally going on in all soils, there are many and very soluble substances produced which, if permitted to accumulate in the soil unduly, would render every field unproductive, because in that case the soil moisture would come to possess a too high salt concentration. The proof of this world-wide tendency of soil and rock weathering to produce highly soluble salts is found both in the accumulation of alkalis at the surface, causing sterile lands in all arid regions, and in the saltness of the ocean water, in which land plants cannot grow, and which has been rendered saline by leachings from the soil. And so, notwithstanding the fact that we regret the loss of plant food from fields by leaching, ample drainage, which will ensure this leaching, is indispensable to the continued maintenance of soil productivity. Indeed one of the great dangers in the cultivation of arid lands results from the difficulty of not being able to supply sufficient good water to the fields to ensure enough of leaching to carry away the highly soluble products of soil decay, and thus prevent them from rendering soil moisture too highly concentrated for the endurance of plants. Voelcker's analyses of drain waters from the Rothamsted Broadbalk fields show that they carry, as an average, 100 lb. of soluble substances per acre and per inch of rain drained away, and Reade places the dissolved solids carried to the sea yearly by the run-off from England and Wales at 8,370,630 tons.

Not only must land be drained in order that it may remain permanently productive, but it must be *underdrained*, and to the depth at which the roots of crops may feed to advantage, for the reason that wherever the rainfall is sufficient to meet the needs of large crops it is more than enough to fill with water the open space in soils to a depth of 5 ft.; so that without underdrainage the most rolling fields and even steep mountain slopes would necessarily possess the character of swamp lands. There are very few plants which will not thrive well with their roots entirely immersed in open free water holding in solution sufficient plant food, provided it can be kept abundantly supplied with air. Under these conditions the Mexicans and Chinese cultivate their floating gardens. But in water-filled soil it is impossible to have a sufficiently rapid change of air to meet the demands, and hence the roots of cultivated plants will and can only develop in the well-drained depths of any soil, no matter how much plant food may be present or how readily permeable it may be.

There are but few agricultural crops which, when established on a deeply drained rich soil, in good physical condition, will not send their roots out and down so as to occupy the soil of the whole field to a depth of 3 to 4 ft., or even further. This would hardly be the case if crops did not find it to their advantage to do so. The truth of this statement regarding the deep distribution of the roots of crops in the soil of a field is made clear by figs 1 to 4, all of which are reproduced from photographs of roots taken from field soil where the crops had grown under natural field conditions, the roots having been obtained by carefully washing away the soil with a gentle spray of water. The soil in which these crops grew was a strong loamy clay underlaid by 3 ft. of red gravelly clay followed by a gravelly sand, with the level of the ground water, at the time of the maturity of the crop, 6 to 8 ft. below the surface of the field. It will be seen that the roots of the winter wheat, oats, timothy and red clover, have all reached a depth of nearly 4 ft., while an instance may be cited of a grape vine (nine years planted) growing where the surface was 12 ft. above ground water, whose roots had penetrated to a depth exceeding 6 ft. Looking at the roots of winter wheat in fig. 1, it will be seen that a mass of other roots have been entangled with them at a depth of 2 to 3 ft. below the surface. These are from a second growth black oak standing 33 ft. distant from the place where the samples of wheat roots were taken. It must be clear, then, that the roots of agricultural crops need and will use a great depth of soil if only such be made available to them by having the soil sufficiently drained, fertile, and in good physical condition. From this it follows that no soil can be given its maximum productivity unless the surface of the ground water is maintained by underdrainage at a level at least 4 ft. below the surface.

Crops on soils deeply underdrained suffer less in times of drought, and are much better supplied with water at all times, than where the roots must develop close to the surface in consequence of lack of efficient drainage. In growing plants in the shallow soil on greenhouse benches, not only must the soil be very highly fertilized, but it requires watering very frequently. In the field, when crops are forced to root shallow with the soil only moderately fertile, not only is there a small amount of food placed in reach of the roots, but unless the rains are frequent and falling in right amounts, the crop must necessarily suffer from drought, even when a saturated soil lies only a foot or less below, for the rate of capillary rise into a dry soil, impeded by the strong action of the

roots, is much too slow to meet the needs of the crop.

When rains do fall on a well-drained field in good structural condition the water sinks at once deeply, spreading itself over a wide extent of root surface, at the same time carrying down the soluble plant food material from the immediate surface of the field, where it tends to accumulate through capillarity and evaporation, and placing both food and water in direct contact with growing roots, where it must have its highest possible efficiency, not only because it has been placed where it is needed, but because much less of it can be lost by immediate surface

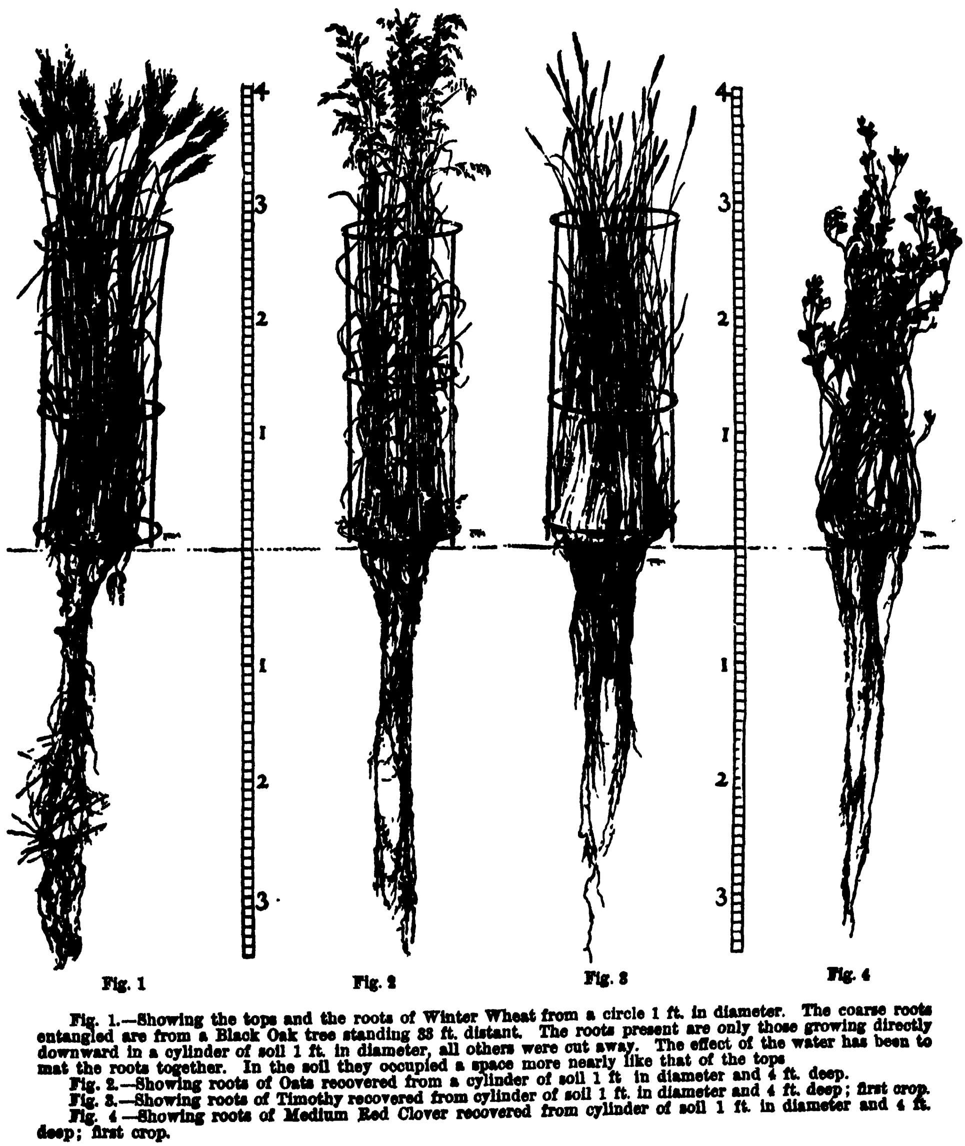


Fig. 1 Fig. 2 Fig. 3 Fig. 4

Fig. 1.—Showing the tops and the roots of Winter Wheat from a circle 1 ft. in diameter. The coarse roots entangled are from a Black Oak tree standing 33 ft. distant. The roots present are only those growing directly downward in a cylinder of soil 1 ft. in diameter, all others were cut away. The effect of the water has been to mat the roots together. In the soil they occupied a space more nearly like that of the tops

Fig. 2.—Showing roots of Oats recovered from a cylinder of soil 1 ft in diameter and 4 ft. deep.

Fig. 3.—Showing roots of Timothy recovered from cylinder of soil 1 ft. in diameter and 4 ft. deep; first crop.

Fig. 4—Showing roots of Medium Red Clover recovered from cylinder of soil 1 ft. in diameter and 4 ft. deep; first crop.

evaporation, or can be carried off directly from the surface, producing damage by surface erosion.

Soils deeply and continuously drained, so that rains sink at once beneath the surface, are not only warmer than similar soils not well drained, —because there is less cooling from excessive evaporation at the surface,—but many conditions conspire to put the soil throughout its root zone into better physical, chemical, and biological condition, and to maintain it so. Roots penetrating more deeply produce in the best way a strong subsoiling effect, and do it incidentally, without material expense to the owner. Organic matter is disseminated to the depth the roots penetrate, and to the extent of their mass. The drying of the soil deeply by root action causes it to shrink and check, making it more

permeable to water, air, roots, and fertility-producing organisms. The roots excrete carbon dioxide, as do some soil organisms enabled to feed upon the deeper organic matter, and this acid acts as a solvent to materially increase the immediately available plant food, and the lime especially, so dissolved, becomes an available base to unite with nitric and other acids formed through the life activities of micro-organisms; while the carbonate not so used tends to flocculate the clay, giving to the soil a stronger granular structure, which means better physical condition and better crops.

When close-textured soils have once become deeply and extensively checked, bored by earthworms and ants, and strongly granulated or formed into crumbs, with the open spaces between them well lined with living and decaying roots, they have been brought into a seemingly paradoxical but extremely wholesome condition, in which the surplus water is allowed to drop quickly through the soil to escape into the drains, but with relatively less leaching or loss of plant food than must result when the soil is less open and the water is compelled to pass away more slowly. The securing of this condition in heavy soils is so extremely important—indeed it is the culmination of the object of drainage in such cases—that the manner of soil action when in this condition should be clearly understood.

Condition of Soil Moisture as regards Freedom of Motion.—The water present in a field soil, when completely filled, is there under three degrees of freedom of motion: (1) That which will drain out under the stress of gravity —*gravitation water*; (2) that retained against gravity, but which may move in all directions under surface tension—*capillary water*; and (3) that which moves appreciably neither capillarily nor in response to gravity, but is much more nearly stationary upon the immediate internal soil surfaces —*fixed water*. In this fixed water the soluble salts, or immediately available plant food, appear to become most strongly concentrated, and for this reason can be lost by leaching only very slowly, especially from a soil in condition to drain quickly. In the capillary water the soluble salts and immediately available plant food materials possess an intermediate concentration, and these may be carried in any direction through the soil with the capillary flow. In the gravitational water the concentration is least, the amount of soluble salts present depending (1) upon that present in the rain as it falls, (2) upon that dissolved from the immediate surface of the ground, and (3) upon the amounts which may pass by slow diffusion from the capillary and fixed water into it while it is passing through the soil on its way into the drainage channels.

The finest grained soils, like the heavy clays, after they have become strongly granulated are able to retain the largest amounts of fixed water, the largest amounts of soluble plant food materials, and for these reasons lose least plant food in rapid leaching or quick drainage. The fixed water is drawn inside the soil granules, and with it also the soluble salts, while the capillary water invests the granules with more or less intergranular penetration, depending upon the size and openness of the crumb or grain units. With the water and the soluble salts thus retained, it is clear that there must be less leaching as the excess or gravitational water is passing through the larger non-capillary channels than there would be from a largely single-grained sandy soil.

It must be clear also that any type of soil where the gravitational water remains long or moves slowly through its channels, must become more completely saturated with salts passing by diffusion from the capillary and fixed soil water, and hence relatively larger amounts must be carried into the drainage water under these conditions. But when deep and ample underdrainage is provided, so that the roots of crops may fully occupy the surface 3 or 4 ft. of soil, they are able to draw on all the capillary water, which is being continually charged by the process of diffusion with plant food from the fixed water; and when percolation from rain occurs, this gravitational water is drawn upon until the loss of capillary and fixed water is restored, and if the excess water can quickly pass away below the root zone, the loss of essential plant food will be relatively small. To secure these structural conditions, and to provide quick and easy escape for excess water from the soil, is the prime or chief end of underdrainage. Ideal cultural conditions for a field exist when all ordinary rains may directly enter the soil where and as they fall; when the rains percolate downward just rapidly enough for the soil to take up its full charge of capillary and fixed water, and when only that in excess of this passes beyond the root zone to drainage outlets.

Ground Water.—Of the water which falls as rain upon the land, one portion may find its way at once into drainage channels, a second portion may be evaporated where it fell, while a third may enter the ground. The portion which enters the ground and is not returned to the surface by capillarity or by root action fills the pore spaces in the soil and subsoil or underlying rock, constituting what is known as the ground water. This ground water is the source of supply for wells, springs, and streams, and is the water which should be removed by underdrainage wherever the ground-water surface rises into the root zone.

The maximum amount of ground water which may be retained by field soils is measured by the amount of open or pore space between the soil grains, and varies with different soil types, as will be seen from the table at top of p. 185, representing a series ranging from a coarse sandy soil to a rather heavy clay type.

This table makes it clear that most soils, in their upper 4 ft., have capacity for storing from 18 to 24 in. of rainfall, and that the differences between the maximum capacities in soils of different types are not very great. A field is ideally drained when it may absorb the rain as rapidly as it falls, and is able to permit that not needed for capillary saturation to escape below the zone of root action in at most from twenty-four to forty-eight hours after the rain. The capacity of a soil for receiving rain is measured by the difference between the amount of water

Table showing pore space and absolute water capacity in the surface 4 ft. of eight soil types, computed on an assumed specific gravity of 2·65 for the soil grains

		1st Foot.	2nd Foot.	3rd Foot.	4th Foot.	Total for 4 ft.
Hagerstown clay loam ...	Pore space,	57·37%	44·87%	38·79%	35·68%	—
	Water ...	6·88″	5·38″	4·65″	4·28″	21·19″
Hagerstown loam... ...	Pore space,	55·23%	44·55%	38·68%	34·36%	—
	Water .	6·63″	5·35″	4·64″	4·12″	20·74″
Janesville loam	Pore space,	58·59%	50·69%	47·72%	42·61%	—
	Water	6·91″	6·08″	5·73″	5·11″	23·83″
Miami loam	Pore space,	52·59%	48·75%	46·61%	44·52%	—
	Water ..	6·31″	5·83″	5·59″	5·32″	23·05″
Selma silt loam	Pore space,	51·43%	48·60%	47·34%	43·50%	—
	Water	6·17″	5·83″	5·68″	5·22″	22·90″
Sassafras sandy loam ...	Pore space,	51·95%	44·87%	44·10%	46·42%	—
	Water ..	6·23″	5·38″	5·29″	5·57″	22·47″
Norfolk sandy soil ..	Pore space,	47·43%	41·99%	34·57%	30·64%	—
	Water ..	5·69″	5·04″	4·15″	3·68″	18·56″
Norfolk sand . ..	Pore space,	48·43%	44·47%	40·00%	41·95%	—
	Water ..	5·81″	5·34″	4·80″	5·03″	20·98″

present in the soil at the time of the rain and its maximum capacity. In the case of the eight soils included in the preceding table, the amount of water carried during the growing season was carefully determined at different intervals between April and September of 1903, when the rainfall had been well distributed, falling in moderate amounts at a time, and measured, for the first two soils, 18·87 in.; for the second two, 18·75 in.; for the sixth and the eighth, 19·78; and for the fifth and seventh, 19·44 in. In the next table is given the total amount of water the respective soils are able to retain in the surface 4 ft., the actual amount present, together with the differences, the latter measuring the capacity of the soils for receiving rain.

Table showing the capacity of soils when in good moisture condition for receiving additional rainfall

	Absolute capacity in inches.	Water present in inches.	Available capacity in inches.
Hagerstown clay loam	21·19	17·21	3·98
Hagerstown loam..	20·74	17·13	3·61
Janesville loam	23·83	14·68	9·15
Miami loam	23·05	9·97	13·08
Selma silt loam	22·90	16·38	6·52
Sassafras sandy loam	22·47	12·95	9·52
Norfolk sandy soil	18·56	12·78	5·78
Norfolk sand	20·98	11·17	9·81

The Janesville and Miami loams, which have the largest absolute water capacity, are naturally the best-drained soils, formed by the decay and weathering of a coarse limestone gravel left at the overflow in front of a glacial moraine, the gravel being 100 or more feet deep, and rising to within 5 to 8 ft. of the surface, the gravel itself being deeply drained. Here there is a very large water capacity combined with the quickest and most direct underdrainage possible. But even the two clay soils possess an available capacity of more than 3 in., so that if only adequate underdrainage is provided, and they are duly open in texture to the full depth of 4 ft., there is ample opportunity for receiving the water as it falls in all but the heaviest rains, leaving little or none to leave the field by surface drainage. Where sufficient fall exists, and an outlet for the underdrain is available, the only serious difficulty likely to be encountered is that of developing and maintaining the proper structural condition in the soil above the level of the drains.

It is only in wide reaches of flat country that the surface of the ground water is horizontal or concentric with the surface of the land. Nearly everywhere the ground-water surface rises and falls with the surface of the land itself, but less abruptly, the water level being lowest in the valleys and highest under the hills. Streams and permanent lakes are always extensions of the ground water above the level of the solid earth, and constitute the natural drainage outlets into which water is continually flowing along both banks of every stream and across every foot of the entire margin of lakes and ponds. When wells are sunk for water, the depth at which water is found is nearly always at a level above that of the neighbouring streams and lakes, these seldom being the source of the water in the well; there is therefore little danger of the water in the well ever being contaminated by impurities from passing streams, or ponds or lakes near by. Where the well stands but a few feet away and is sunk several feet below the level of the outside water, so that continuous pumping lowers the level of the water in the well below that outside in the lake or stream, and also where the stream is subject to strong rises during times of floods, there may be more or less backward seepage into the ground which might reach a nearby well.

In figs. 5 and 6 the configuration of the land surface and that of the ground water beneath

are represented by contour lines, the arrows in the fig. showing the direction or tendency of the water to flow along lines at right angles to the

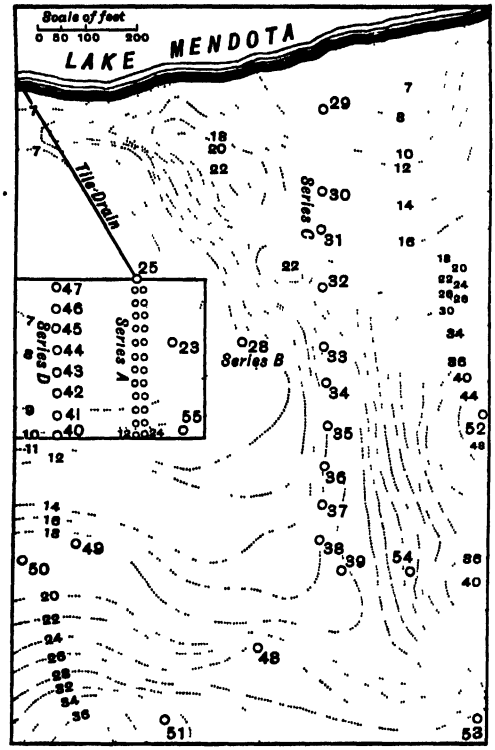


Fig. 5.—Contour map of surface of ground above the ground water of fig. 6.

contours, or in the direction of the steepest descent, just as would be the case with water flowing along a land slope.

The area bounded by the rectangle on the left in the two figures, and from which a tile drain leads to the lake, is where the underflow from beneath the higher parts of the field, coupled with the rainfall, causes the ground water to rise so close to the surface that underdrainage becomes necessary. At 52 on the right margin of the field, marked 'pumped well', the amount of water used from the well is so large that the ground-water level is permanently changed, a depression being formed toward which the water flows in the reverse direction from what had been the case before the well was dug and used.

The two illustrations make it clear that the rains tend to sink directly into the land, and then, after accumulating to levels above the surface of lower areas, tend to drain away toward these lower areas along the lines of steepest descent and least resistance. In a well sunk in the same hill stretching eastward from the right margin of the diagram, and where the surface rises to a level of 88 ft. above the lake, the water in the ground stands, during the wettest portion of the year, some 52 ft. higher than the level of the lake, whose shore line is but 1200 ft. distant. This means that a head of 52 ft. is required to overcome the resistance to the flow of water offered by the 1200 ft. of earth materials into which it has sunk, and through which it must drain in reaching the outlet at the lake.

The Escape of Underground Water into Drainage Channels.—Whenever rain falls upon a field, no matter how steep the slope, its first tendency is to continue the course it was pursuing when it fell and to pass directly beneath the surface in a straight line, and it is only when the rate of precipitation exceeds that at which percolation takes place that there is any surface movement toward drainage channels.

The water which enters the ground in excess of capillary saturation moves directly downward until the ground-water surface has been reached, when it raises that level and at once augments the pressure tending to produce lateral flow. If the land were everywhere level the effect of percolation would be simply to raise the ground-water surface; no lateral movement would be possible except under such conditions as permitted the ground-water level to be lowered more rapidly in one place than in another by surface evaporation, aided by capillarity and root action through the transpiration of plants. With differences of surface elevation, however, which are always associated with topographic forms,

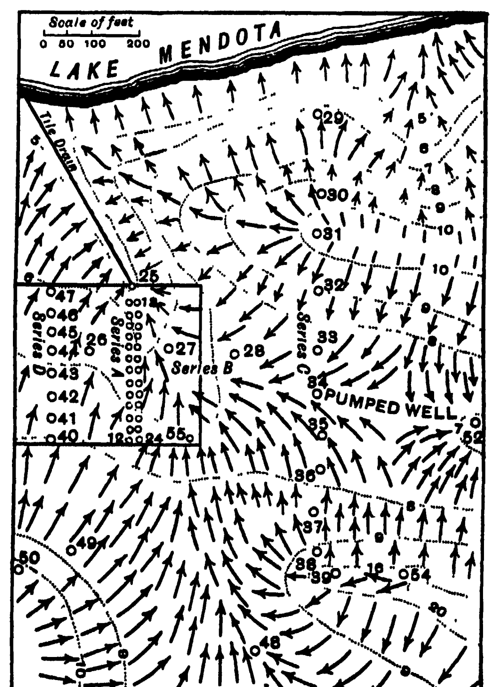


Fig. 6.—Contour map of surface of ground water. Numbered circles, location of wells; figures in lines, elevations of contours; arrows fly with direction of current.

and with the far greater resistance opposed to lateral flow, as compared with that which impedes movement directly downward, it is evident

that the water which sinks beneath the surface of land areas must tend to accumulate beneath the places where it has fallen, until a sufficient pressure has been developed to force the flow through the soil and rock toward whatever drainage outlets may exist.

The surfaces of rivulets, brooks, streams, rivers, and lakes, with but very few exceptions, lie below the level of standing water in the ground which is adjacent to them, as has been stated, and from which almost everywhere water is steadily but usually slowly flowing into them.

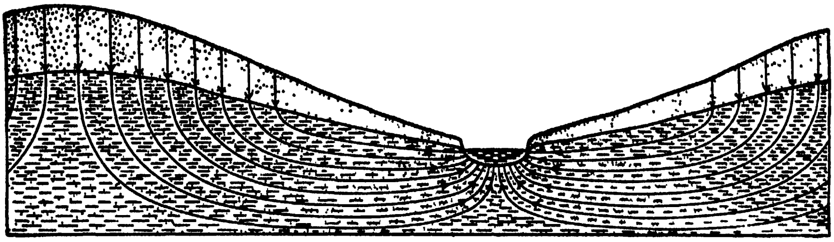


Fig. 7.—Diagrammatic section illustrating seepage and the growth of streams. Lines with arrows are lines of flow

Rivers generally receive new acquisitions of water at every point along their banks, there being a slow but general seepage from the surrounding higher lands. The same is true of lakes. Springs, it is true, are feeders of both lakes and streams, but these are only underground extensions of channels into which the same type of slow seepage occurs, the water oozing through the walls of the subterranean channels just as water is gathered into a system of tile drains, not at any one point, but little by little along the entire course. Indeed the old-time closed clay drains were exact reproductions, in principle, of nature's subterranean drainage channels.

There are cases, it is true, where mountain streams flow out upon arid plains in which the direction of seepage is reversed and the water wastes outward from the channel, ultimately leaving the bed of the stream dry; but in these cases such portions of these waters as are not lost by evaporation are certain to reappear again farther down the valley, adding to the growth of rivers there. In other cases, rivers may move down upon a sandy plain, perhaps underlain by a sandstone formation or an extensive gravel bed which is deeply underdrained, so that the ground-water level lies below the bed of the stream; and in such instances the stream loses in volume rather than increases as it moves along its course. In still other cases a shallow soil may be spread out upon a much-fissured limestone formation which, by reason of slope or cliff exposures, is so thoroughly underdrained that no ground-water surface can be maintained above the stream bed; and here, too, the water may slowly waste away, or, in exceptional cases, brooks may disappear abruptly beneath the surface only to reappear farther down the valley in the form of a powerful spring.

A general principle underlying the sinking of rain into the soil to maintain the ground water level, and the flow of the ground water itself to find outlets in streams or lakes, is illustrated diagrammatically in fig. 7, where the continuous curved lines with arrowheads indicate the general course of water movement on its way from ground surface to outlet.

The growth of a river through the general seepage or underflow of water into its channel is well illustrated in the case of the Los Angeles river in California, a section of which is represented in fig. 8, where contour lines show the

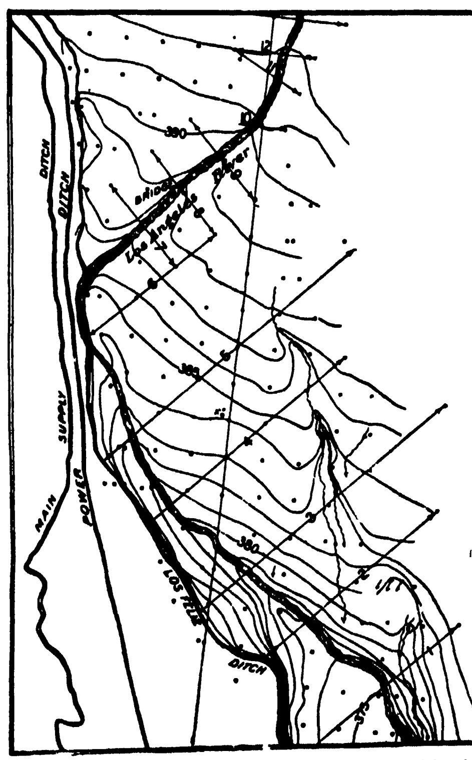


Fig. 8.—Map of section of Los Angeles river, California, showing level of the ground water in the portion where the growth of the river by seepage was measured.

rise of the ground-water surface both up the valley and extending outward from the river channel. Careful measurements of this stream at two points in its course have shown that in a linear distance of 59,088 ft. the water in the river increased in volume from 20·41 cu. ft. per

second, at the upstream point, to nearly 80 cu. ft. per second some eleven miles below. This is a rate of seepage into the river channel along its bank and bottom of very nearly 1 cu. ft. per second for each 1000 ft. in length of channel.

When stream channels or lakes into which drainage takes place have low banks, and wide stretches of land intervene between them and higher ground, and especially if beds of porous material underlie these flat areas, the water level under these flat lands will be maintained very close to the surface, and even springs may form in many places. In such tracts, underdrainage would be very necessary to bring the land into cultivable condition, and the drains would be required to carry away both the excess of rainfall percolating into the low-lying land, and enough of the underflow to hold its level below the proper depth for the root zone.

Changes in the Ground-Water Level.—The impounding influence of all porous lands lying above drainage levels causes the ground-water surface to rise during wet seasons, while during dry ones it falls, so that the effective head in wells and in springs, as well as that which causes the ground water to rise into tile-drained fields, is increased or decreased periodically in accord with the fluctuations of the rainfall, and of those other conditions which tend to diminish the amount of water entering the land. In the same manner, also, the capacity of ordinary wells to supply water varies as the general level of the ground water rises and falls. In the locality represented by figs. 5 and 6, the level of the ground water is determined almost wholly by the percolation of purely local rains. The wells in Series C, which are in the higher land and most remote from the system of drains, are well suited to show the long-period fluctuations due to the quantitative relationship existing between the amount of rainfall and the rates of drainage and percolation. When this line of wells was sunk, in August, 1888, there was water in all of them except 31 and 36, and the level of the water in them at that time is shown in fig. 9 on a stated date, and also on stated dates for

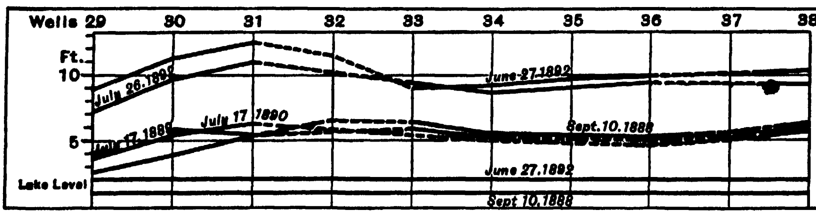


Fig 9.—Showing profiles of ground-water surface along wells of Series C, figs 5 and 6, for different dates and years.

the years 1889, 1890, and 1892. During the latter part of the summers of 1889 to 1891, inclusive, all of the wells in this series became dry except No. 30, which is nearest the lake, and in each case it has been true that after going dry they did not contain water again until after April 1 the following spring.

It will be seen that the surface of the ground water in June, 1892, was 4 to 5 ft. higher than in any other season covered by the records. The level of Lake Mendota was also higher. When in the spring of 1892 the surface of the ground water first began to rise above the level of the bottoms of the wells, its surface had become very nearly horizontal. Between May 21 and June 7 there had been a mean rise for the entire line of wells of 1·5 ft., associated with a rainfall of 4·02 in. Between June 7 and June 27 the mean rise was 2·38 ft. more, and this was associated with 4·97 in. of rain. The total rise between May 21 and June 27 was 3·88 ft., and the rainfall during the same period 9·05 in. During the first of these periods the water rose at the rate of ·373 ft. per inch of rain; in the second period ·479 ft., and during the whole ·428 ft. per inch of rain. The general mean of all observations made in this field showed a rise of about ·42 ft. in the ground water for each inch of rain.

Determinations made regarding the open space in these soils showed it to be about ·4 cu. ft. in 1 ft. of the dry sand which formed the subsoil, and that capillarily saturated sand, standing 1 ft. above water, such as the rise here considered took place in, would contain about 18 per cent of its dry weight, while the dry weight of the sand was not far from 105 lb. per cubic foot. Under these quantitative relations the capillary water should occupy ·32 cu. ft., so that the unoccupied space into which water could percolate would be only ·08 cu. ft. Under these conditions an inch of rain, with the soil capillarily saturated, should fill a cubic foot of soil more than full; but as the ground water only rose at the mean rate of about ·42 ft. it follows that either the soil did not contain 18 per cent of its dry weight of water at the time the rains occurred, or else that there was during that time a very considerable seepage from the area. Both of these conditions probably represent the fact. The surface of ground water, therefore, is subject to very appreciable changes of level, some of which are seasonal, some associated with individual rains, and others which cover longer periods, being associated with a series of dry or a series of wet years.

There is a very material difference in different soils in the amount of rise in the ground-water surface which will be produced by a given amount of rain, due to the fact that the soils of finer texture remain more nearly filled with the capillary and fixed water, to greater heights above standing water, than do those which are coarser. It is also true that the first inch of rain which percolates to the ground water produces a greater change in the level, and therefore a

greater increase in the rate of seepage, than succeeding like amounts do. This is owing to the fact that the amount of unoccupied space in soils just above standing water increases slowly at first, then quite rapidly, and finally again more gradually as the distance above the ground water increases. These facts are represented graphically in fig. 10, and are stated numerically in the next table.

In the illustration the distance between the heavy horizontal lines is 1 ft., the lighter ones representing quarters, and each unshaded area, numbered 100, 80, 60, 40, 20, represents the amount of space not occupied by water after the respective sand columns, 8 ft. long, had been allowed to drain more than two years under conditions where almost no evaporation could occur. Each unshaded empty space is to be understood to apply to the whole figure, which represents the relative thickness of the respective sand columns. By comparing the empty space in the finest or No. 100 sand with that in the coarsest or No. 20 sand, it will be seen that a given amount of rain will raise the water

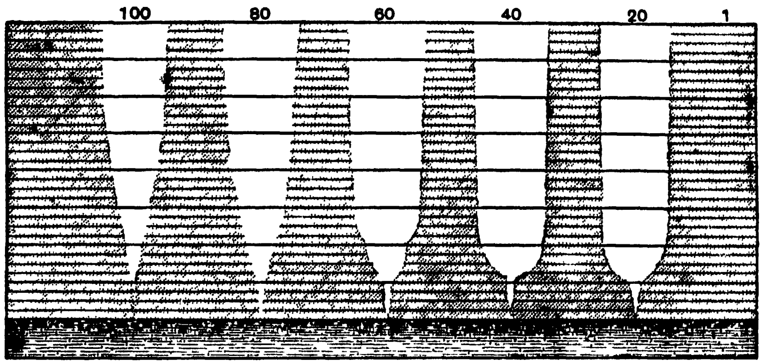


Fig. 10.—Diagram showing unoccupied space in sands after two and a half years of seepage, without rain or evaporation. Numbers designate grade of screen; horizontal lines drawn at distances of 3 in.; open space in each case applies to whole section; lower shading is ground water

level much more in the finest than it will in the coarsest sand. These differences are more explicitly given in the table, where the amounts of rain in inches required to raise the water level 1, 2, 3, and 4 ft. are stated.

Table showing amount of rain necessary to raise the level of ground water in sands after thorough drainage.

	1 ft.	2 ft.	3 ft	4 ft.
	inches.	inches.	inches	inches.
No. 20, diameter ·475 mm.	·874	4·379	8·550	12·81
No. 40 " ·185 "	·579	3·551	7·795	12·19
No. 60 " ·155 "	·433	2·701	6·454	10·80
No. 80 " ·118 "	·370	1·592	4·080	7·573
No. 100 " ·083 "	·242	1·030	2·635	5·131

From this table it will be seen that the first foot of rise in the ground water is effected by less than ¼ in. of rainfall in the finest sand, while ·874 in. of rain is required to produce the same amount of rise in the coarsest sand; and so, while the first foot of rise in the finest sand is accomplished by the percolation of ·242 in., the second foot of rise requires 1·03 in. additional, the third foot 2·635 in., and the fourth foot 5·131 in. additional, when the rainfall is continuous, and supposing, of course, that no underflow from the region takes place.

The observed changes in the level of the ground water following a rain of 3·19 in., which occurred in the west half of the drained area along the line of wells designated Series D in figs. 5 and 6, are represented in fig. 11. The distribution of the rainfall in time was as follows: June 2, from 7.30 a.m. to 9 p.m., 1·38 in.; June 3, 7 a.m. to 2 p.m., ·41 in.; 9 p.m., June 3, to 7 a.m., June 4, 1·18 in.; 9.15 p.m., June 4, to 6.30 a.m., June 5, ·22 in., thus covering an interval of three days.

The measurements of the water level were made June 2, before the rain; then June 3, at 3.30 p.m.; June 4, at 9 a.m., 2 p.m., and 7 p.m.; and finally, June 6, at 1 p.m.; and the profiles of the water level are shown in the figure, and are numbered from 1 to 6 in the order they were made. The surface of the ground at Well 40 is 3·3 ft. higher than it is at Well 47, as shown by the contour map, fig. 6, and the texture of the soil increases in fineness from Well 40 toward

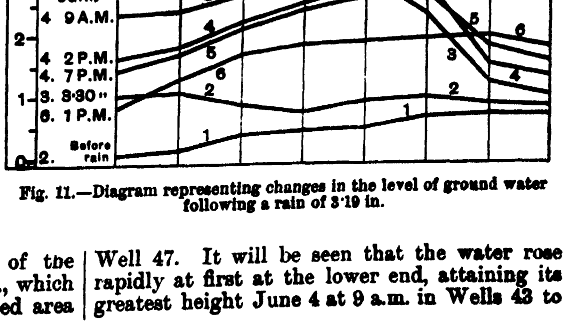


Fig. 11.—Diagram representing changes in the level of ground water following a rain of 3·19 in.

Well 47. It will be seen that the water rose rapidly at first at the lower end, attaining its greatest height June 4 at 9 a.m. in Wells 43 to

47, but that in Wells 40 and 41 the water continued to rise until June 6 at 1 p.m.; but at this time the water in Well 47 had reached its highest point, and had fallen through a distance equal to that through which the water in Well 40 had risen.

The rapid fall of the ground-water surface in the region of Wells 47 and 46 is to be attributed in part to the fact that tile drains occupy the area and offer much shorter drainage lines than would otherwise have to be traversed by the water. In the region of Wells 40, 41, and 42 the ground rises so that the lines of tile are entirely above the level attained by the ground-water surface on June 6, so that here only a small portion of the early falling away of the water could have been directly influenced by the artificial drainage. It is of course true that the normal rate of fall of the ground water of this particular locality was increased by the increased pressure due to the rise of the water in the ground at this time, so that the full rise of water in the ground, produced by the 3·19 in. of rain, cannot be stated without applying a correction which allows for the amount of water which drained away during the interval under consideration.

The actual observed contour of the ground-water surface as it existed 48 hours after a rainfall of ·87 in. in the east side of the drained area, represented in figs. 5 and 6, is shown in fig. 12.

To determine the actual contour of the ground-water surface in this tile-drained field when the drains were doing duty, a line of seven test wells was sunk midway between the lines of tile, which are laid in the area designated, as nearly as may be 33 ft. apart, and at distances below the surface of the ground of about 4 ft. The wells referred to are therefore 16·5 ft. from the drains on either side. They were also at a distance not exceeding 30 ft. from a line of a main drain into which this series of laterals discharged. The soil of the locality consists of 6 to 8 in. of medium clay loam, followed by 2·5 to 3 ft. of clay, below which is a stratum of rather coarse sand, and in the upper surface of this sand the tiles are usually laid. The tiles are 3 in. in inside diameter, and laid on a grade of 2 in. in 100 ft.

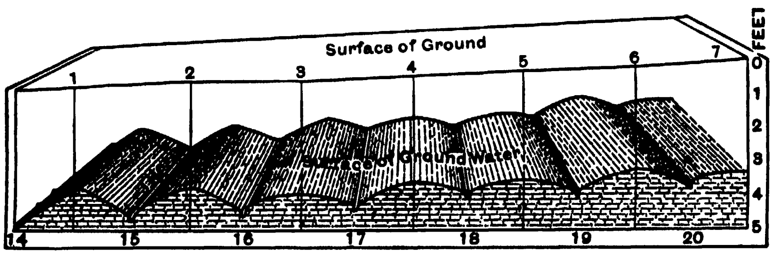


Fig. 12.—Surface of ground water between tile drains 48 hours after a rainfall of ·87 in

At the time the levels were taken the tiles were discharging less than one-twentieth of their capacity. The highest water level in any well between these lines of tile at the time of observation, when referred to the tops of the tile between which the wells are located, was 1 ft. in the case of Well 1, above Tile 14, and the least was about ·3 ft. in the case of Well 5, above Tile 18. Both Wells 5 and 3 were sunk into a sand containing some gravel, and to this fact is probably due the less steep gradient at these places. Between Well 2 and Tile 16 two other wells were sunk, one 2 ft. from the drain and the other midway between the drain and Well 2. In the well 2 ft. back from the drain, water stood ·3 ft. above the top of the tile, and in the other, ·45 ft. above; the profile would present, therefore, a more or less curved contour, convex upward, as has been represented in the diagram.

History. — There appears little reason to doubt that the early history of land drainage for agricultural purposes, like that of irrigation, far antedates authentic history. When it is recorded that 'the numerous remains of huge tanks, dams, canals, aqueducts, pipes, and pumps in Egypt, Assyria, Mesopotamia, India, Ceylon, Phœnicia, and Italy prove that the ancients had a far more perfect knowledge of hydraulic science than most people are inclined to credit them with', it can hardly be doubted that the improvement and reclamation of land by drainage would in the same times have engaged the energies of other peoples where the conditions were such as to make efforts along these lines fruitful. Indeed it would hardly be possible that such extensive irrigation systems as long antedated the Christian era could have attained to the magnitude and perfection they did, without the complementary art of land drainage being forced to make much progress even as a necessary aid to irrigation itself.

Among the early agricultural writers who treated of land drainage are the Latin author Columella, writing shortly after the beginning of the Christian era, and Palladius, writing between 300 and 400 years later. Each of these writers speaks of both open and closed drains, of their proper depths, and of the methods of constructing those which are closed by filling into the bottoms of 3-ft. trenches, to half their depth, small pebbles, pure gravel, or, where these are not available, bundles of sticks, which were to be covered with leaves or litter, and finally with the earth removed, leaving the surface smooth and level. There are indications that the Romans were familiar with and used clay pipes for drainage works in many of the places where they established themselves in different portions of Europe, as in France, Austria, Saxony, and in other countries.

It was discovered at the time of remodelling a former garden adjacent to a convent of monks in the town of Maubeuge, in France, near the Belgian frontier, that this garden was underlaid at a depth of 4 ft. with two systems of pipe drains extending throughout the garden, whose fertility had been a matter of common remark for a long time. One of the systems had all its pipes radiating from a sinking well occupying a central position, while in the other they were laid parallel, ending at a collecting pipe supposed to discharge into a cellar. The pipes were about 4 in. in diameter, 10 in. long, funnel-shaped at one end and tapered at the other, thus being in principle entirely like modern sewer tile. There are some things regarding the association and arrangement of the systems which suggest that they may have been laid for the purpose of sewage disposal for the convent rather than as a drainage system for the garden; but whatever the purpose of the system may have been, the facts show that cylindrical burned clay tiles were manufactured and in use earlier than 1620 A.D., because there were tombs of this date placed above the tiles.

Between 1600 and 1620, when Oliver de Serres was writing on agriculture in France, attention was called both to the importance of drainage and to the methods of securing it, he designating the main ditch a 'mother trench', and a system with its branches a 'hen's foot'. He describes the method of constructing closed stone drains, and advocates the use of rye straw as first choice of material and wheat straw as second, where small stone or coarse clean gravel are not readily available. He speaks of the need of using masonry with mortar to secure permanent and free outlets, especially for main drains, and gives specific instruction regarding proper depth, and of the need of increasing the number of drains where straw is used, rather than their size, when insufficiency of capacity is feared, on account of the danger of clogging by caving in of walls.

The earliest literature on land drainage by an English writer appears to be that from the pen of Captain Walter Blith, under the title The Improver Improved, which appeared as early as 1650 (see BLITH, WALTER). Blith appears to have clearly recognized and stated the chief practical problems of land drainage, and specified many of the necessary steps which must be taken in their solution so far as was practicable in his time. He clearly distinguished between lands maintained wet by the underflow from surrounding higher ground and other types, and recognized the need of applying especially deep drainage to the former cases. He clearly appreciated that the best treatment for a given piece of land can only be determined after a careful study of its specific conditions. But the more or less temporary character of all of these early efforts at land drainage, due to the fact that however the covered drains were constructed, sooner or later they became clogged and ineffective, led to discouragement, and to the final abandonment of drainage operations for a time, until those who had suffered disappointment, and their children who knew of the failures, had passed away. Then, with the evils of insufficient drainage still present, and without knowledge or full appreciation of the facts and conditions which had led to past disappointment, the old problems were attacked again and again.

And so it happened that, after the lapse of a full century, following the movement for which Oliver de Serres in France and Walter Blith in England stand, another movement sprang up, led by Joseph Elkington, a young Warwickshire farmer who in 1763 inherited from his father a farm called Prince-Thorpe, in the parish of Stretton-upon-Dunsmore. The soil of this farm was poor, and much of it so extremely wet as to cause the loss of many of his sheep through 'rot'; but the young man, who was himself strong, a close observer, resourceful and optimistic, set about to improve his condition by removing the cause of his trouble through a thorough drainage of the farm. His efforts were very successful, so much so as to attract general attention, and after securing like results in the draining of several of his neighbours' farms, he came to be generally employed in this work, and through his native ability and large practical experience extending over thirty years, he came to be very skilful in laying out large drainage systems. So valuable and satisfactory was his practical work, that in 1795 Parliament awarded him £1000 as an appreciation of his services, and Mr. John Johnston, of Edinburgh, was appointed by the Board of Agriculture to visit Elkington's principal works and record the results for the benefit of others. Elkington's great success lay not so much in the application of new principles or practices as it did in his ability to see correctly the factors of his specific problems, and in thoroughly shaping his work to them. By judiciously placing his ditches, digging them deep, and then if he did not strike the water-bearing stratum, conveying water from beneath the surrounding higher lands under that to be drained, using an auger or other means to cut through the impervious bottom, thus allowing a freer escape of the underflow, the thoroughness of his work was made much greater than it otherwise could have been.

With the close of Elkington's thorough and intelligent field practice, but in which he was compelled to use imperfect methods in the construction of closed drains, there came again, as had happened before, a lessening of effort in the direction of land drainage which lasted until about 1831, when the famous James Smith of Deanston, Perthshire, became the leader in opening another period of intensified work along the line of underdraining, when he published a pamphlet under the title Remarks on Thorough Draining and Deep Ploughing, which had been written after the successful draining of a piece of land some years previously, and marked beneficial effects had been observed to follow the treatment. Smith advocated the laying of parallel shallow drains, never over 30 in. deep, at narrow intervals of 10 to 24 ft. over a field requiring drainage, paying little attention to wet and dry appearances. The minor drains were

laid down the steep slopes, while the mains were to be laid along the hollows, and he advocated stone in preference to tiles or pipes for the drains. But the difficulties encountered in procuring and placing the large amount of stone necessary in such construction stimulated inventive skill in the construction of clay tiles, which finally ended in the successful efforts of John Reade, who was the inventor of cylindrical tiles, the first machinery for making which was exhibited in 1843 at the Derby Agricultural Fair.

The reclamation from the sea, by the diking, draining, and warping of such tracts as the fenlands of eastern England and the more extensive areas in Holland, began early, perhaps even before the time of Roman invasion, and these improvements have progressed, with many interruptions and disasters, without obtaining complete subjugation until after 1829, and the substitution of steam power for windmills in lifting the drainage waters lying below sea level. The first serious attempt at drainage in the fen district of England, where there is the great stretch known as the Bedford Level, was begun in 1436, but failed through the storms of the next winter. A second attempt was made by Bishop Morton in 1485, but also failed. Again, in 1602, an Act was passed for reclamation, which failed to secure results, and it was not until 1634 that really successful work began, but only to be interrupted by the civil wars, and again resumed in 1649, when Parliament reinstated the Earl of Bedford's successor in his father's rights. The royal charter to incorporate the company, which still exists, was obtained in 1664, and in 1697 the 450,000 ac. constituting the Bedford Level was divided into North, Middle, and South levels, separated by the Nene and Old Bedford rivers. Finally, effective work of draining was begun by James Rennie about 1810, and carried to completion under Telford, with the later installation of steam pumps.

LANDS WHICH MAY BE IMPROVED BY DRAINAGE.—It has been stated that soil conditions may be improved by underdrainage wherever the zone of *complete saturation* of the soil rises above the depth to which the roots of the crop to be grown will penetrate to advantage, and there are few crops which do not thrive best in humid climates, on soils of whatever type, when the zone of complete saturation in them lies below a depth of 4 ft. Practical experience and experimental research have also shown that the percentage of water saturation of the soil in the root zone which permits the best growth is 50 to 60 per cent of that required for complete saturation, and complete saturation is always found in the soil just above the ground-water level.

The amount of fixed and capillary water retained by a soil after long drainage decreases with the depth of the soil above the level of the ground-water surface, and the rate of such decrease, as it was observed after an interval of sixty days of drainage, where surface evaporation was prevented, is given for two sands and two soils in the next table. The lower line of figures in this table shows what the complete saturation amount of water was in each of the four soils, and 60 per cent of these amounts, or 14·42 per cent for the No. 40 sand, 14·79 per cent for the No. 80 sand, 16·16 per cent for the sandy loam, and 22·31 per cent for the clay loam, are the respective optimum amounts of fixed and capillary water for these soils. The table shows these amounts to be present in the coarsest sand at a level of between 12 and 18 in., and in the finest sand at 24 to 30 in. above standing water, while in the sandy loam and in the clay loam 60 per cent of saturation is exceeded, until a height of 5 to 5·5 and 6 to 6·5 ft respectively above standing water is reached.

Table showing decrease in water content of drained soils, with height above the ground-water surface.

	Sand No. 40 Per cent.	Sand No 80. Per cent.	Sandy loam. Per cent.	Clay loam. Per cent.
78 to 84 inches above water	·19	2·15	16·16	21·16
72 ,, 78 ,,	·42	2·76	16·08	30·70
66 ,, 72 ,,	1·31	3·24	16·55	31·05
60 ,, 66 ,,	1·74	3·74	16·97	31·11
54 ,, 60 ,,	1·87	4·38	17·59	31·21
48 ,, 54 ,,	1·95	5·15	17·99	31·94
42 ,, 48 ,,	2·10	6·51	[illegible]8·70	31·99
36 ,, 42 ,,	2·24	8·09	19·44	32·18
30 ,, 36 ,,	2·57	11·16	20·90	32·45
24 ,, 30 ,,	3·39	14·00	21·71	33·31
18 ,, 24 ,,	5·74	18·16	21·46	34·40
12 ,, 18 ,,	12·02	20·41	22·17	35·54
6 ,, 12 ,,	21·85	22·95	22·68	35·97
0 ,, 6 ,,	24·07	24·65	27·69	37·19

From these data it follows that all soils, unless it be those which are very coarse and sandy, where the ground water is less than 6 ft. below the surface during the crop season, are likely to be improved by underdrainage, because capillary saturation to an extent above 60 per cent of complete saturation is maintained as high as 5 ft. in the sandy loam, and to a height above 6 ft. in the clay loam.

Very explicit and positive knowledge regarding the distance to ground water in a field likel to be improved by draining can be obtained b making borings with a 2-in. auger provide with an extension handle made of gas pip Borings, which can be quickly made in differer parts of the field during both the wet and dr seasons of the year, will show the water leve It should be kept in mind that some hours ma be required in a close soil for the true wate level to be attained in such borings, on accou

of the slow rate of percolation into them. The degree of saturation possessed by a soil may also be determined by drying samples taken with the auger at any desired depth.

In addition to this general statement, for lands subject to regular or frequent inundation, and those like rice fields, water meadows, and cranberry marshes, where water is applied in large volumes which require removal at times, drainage must also be provided.

Kinds of Drains.—Drains for agricultural lands are of two types: (1) open, such as the ordinary streams and channels of nature, and the furrow, ditch, and drainage canal specially provided; (2) closed, such as underground streams, seepage lines, and artificial underdrains. Much the larger proportion of the rainfall on lands leaves, or should leave, them only after having passed into the soil, to be gathered up by seepage lines into underground passageways, to appear at the surface in springs or to be discharged directly into streams; and this is as it should be, for then soil fertility is conserved by avoiding the surface washing of fields. On some fields where the soil granulation is feeble, causing them to break down under heavy rains and run together, the surface pores of the soil become so completely closed that the confined air does not readily escape, and this prevents the water entering, causing sometimes extensive and disastrous surface washing, with loss of productive power, due to both wasted water and plant food materials. With better soil management, supplemented often by underdrainage, such injuries may sometimes be largely reduced.

Open Drains. — Throughout the history of advanced agricultural practice, land drainage has been effected to a greater or less extent in all humid climates through the aid of open ditches and simple water furrows. It is common to-day, and advantageous on extremely flat fields having deep, close-textured, stiff clay subsoils, and only where the local rainfall must be controlled, to plough in lands with shallow dead furrows leading in the direction of the natural slope, whose function is to carry away the excess surface water, which would tend to injure the texture of the soil, cause 'heaving' during the winter, and reduce the yield by permitting too high surface-water content in the soil. By such a treatment, judiciously followed, it has been often possible during a succession of dry years to so effect a structural change in the subsoil, causing it to shrink and check into a multitude of minute blocks, thus rendering it sufficiently open to permit natural underdrainage to ultimately take place, and thus permit the abandoning of the system of surface drainage.

The old Celtic land beds stand as one of the most pronounced examples of detailed surface drainage, the long-continued turning of furrows in the same direction having developed differences in level between crest and furrow in the field to the full height of a man in extreme cases. The water meadows, too, laid out for combined irrigation and drainage as represented in fig. 13, illustrate well such a system of surface drainage, the water flowing away along the furrows represented by the dotted lines, and entering the field along those which are solid.

Open ditches, however, for anything other than outfalls for underdrains, or for removing purely surface water in large volumes, should be brought into service only as temporary or preliminary adjuncts to land drainage. There are extensive marsh tracts which, for the time being, may to advantage be partly drained by open ditches, and to an extent which will render them sufficiently firm for pasture, and which will permit a change in the quality of herbage sufficient to render them serviceable as meadow lands; and such draining may sometimes be done in a manner which will later permit the ditches to be deepened and converted into closed drains, thus making the temporary surface draining serve as a necessary step toward reclamation. Such might well be the case in many bogs where the peat is too deep, spongy, and little decomposed to be advantageously underdrained, on account of the large reduction of level which necessarily follows consolidation, and which would leave lines of underdrains too near the surface.

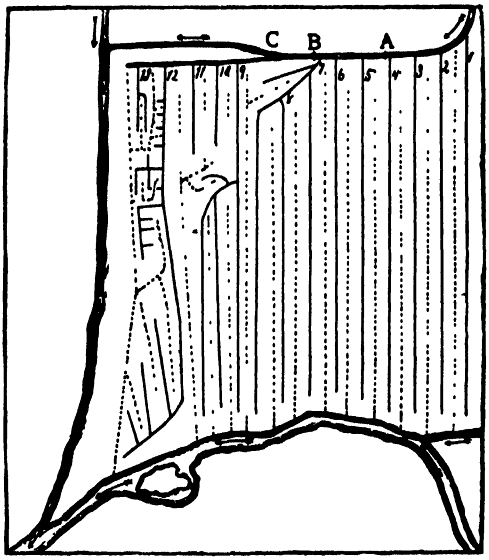


Fig. 13.—Plan of old water meadow, Salisbury, England.

There are local areas, like sinks and ponds and narrow runs or channels, which temporarily receive much water from surrounding fields in times of freshets, which may better be served by open ditches than in any other way. Where depressions exist which tend to fill with surface water, as represented in fig. 14, it is often possible to intercept the excess water above the low area, as at B, and conduct it around along a higher level to the outfall A, and thus avert enswamping the low-lying ground. It is often practicable, in handling such excess water, to so shape the drainage ditches with sloping sides that they may be seeded to grass, and be readily mowed with machines with the rest of the field,

and be driven through without serious hindrance in dry times.

There are many extensive tracts of flat country through which no natural watercourses have been cut sufficiently deep to serve as outfalls for underdrains, and in such cases, on account of greater cost of closed mains of sufficient size,

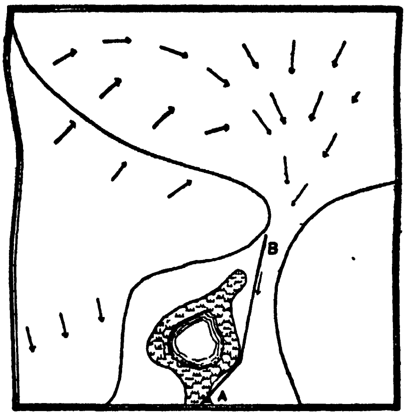


Fig. 14.—Intercepting surface drainage by surface ditch A, B.

or because excessively large volumes of water must be removed, open drains must be used. In such flat districts it is common to find a natural fall or slope of surface amounting to 1 ft. in 1000 to 5000 ft., and it is very important in laying out drainage systems for such districts to secure adequate fall, in order that the velocity of flow may be sufficiently great to enable the water to keep the ditch clean, and thus avoid an annual expense which might be a serious hindrance.

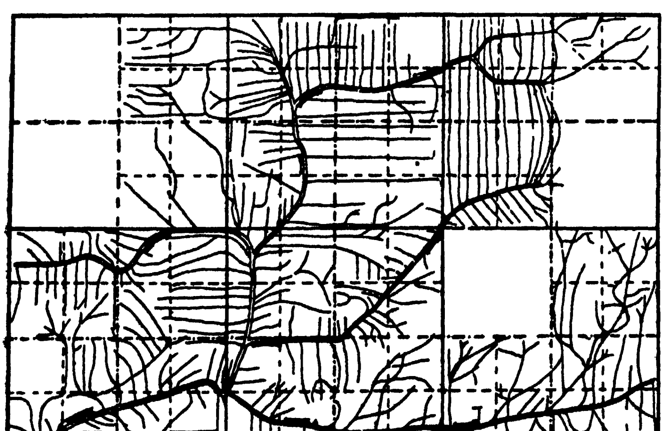


Fig. 15.—Open drainage ditches and underdrains. After J. O Baker. Smallest squares are 40 acres; double lines show open ditches; single lines are underdrains.

In clay soils, which do not erode rapidly, a gradient of 4 ft. per mile will give a safe and effective velocity where the ditch is not less than 3 ft. wide on the bottom, 4 ft. deep, and carries enough water to run three-fourths full at times of high water. But many tracts of land must be drained, if at all, with less fall than this for main ditches and their laterals, and gradients as low as 1 ft. in 2500, or even in 10,000 ft., have been used; but in such cases the ditches were not self-cleaning unless made much deeper and correspondingly wider, so as to secure the necessary velocity through less relative resistance, which is associated with the movement of large volumes of water, both depth and width having the effect of practically increasing the fall, and to compensate for such reduced fall as that just mentioned the drainage ditch must be given a depth of 6 to 8 ft. and corresponding width.

In a ditch 10 ft. wide, falling at the rate of 3 ft. per mile, it is computed that with a depth of ·5 ft. the mean velocity of water will be 1·4 ft. per second; when 2 ft. deep the mean velocity will be 2·6 ft. per second; when 3 ft. deep, 2·9 ft.; when 4 ft., 3·2 ft. per second; when 5 ft., 3·4; 6 ft., 3·6; and when 8 ft. deep the velocity will be 3·8 ft. per second.

When the direction of a large drainage ditch must be changed, it is important to give careful attention to both its form and curvature in order that there shall be as little reduction in velocity of flow, and as little, and as uniform, erosion of the bank as possible in order to avoid expensive protection. In like manner careful attention must be given to both the form and the depth of such drainage ditches in order to secure the highest efficiency at the lowest cost of construction and of maintenance, and at the same time provide sufficiently deep and satisfactory outfalls for underdrains. A slope of 1 to 1 for the sides is considered best for most soils, and as depth of ditches for large areas not less than 5 to 7 ft. should be secured, if possible, since depth decreases the relative resistance to flow, gives better drainage, and greater certainty of self-cleaning.

The capacity required for open drainage ditches depends upon the area and shape of the basin to be drained, upon the slope of the land, and upon the fall which can be secured along the different portions of its course. If the district to be drained is broad and flat, a larger proportion of the rains will be impounded in the soil, and the surface discharge will take place more slowly thus reducing the capacity required; while if the district is narrow, and the slope steep, or broad, and the surface broken or more or less rolling, the run-off will be larger absolutely, and it will take place in a shorter time, thus necessitating larger ditches to control the same amount of water. Even a different shape may be required so as to ensure good scouring at low-water stages, and a large capacity without undue erosion at times of high water.

If the drainage of the district is controlled entirely by open ditches, larger capacity is usually required than where underdrains are used in conjunction with them, for the reason that the run-off will be larger. As a type of drainage districts in a flat country, where open ditches have been required to provide suitable outfalls for underdrains, fig. 15 may serve as an illustration. This district covers an area of 6 sq. miles; the smallest squares represent 40 ac.; the double lines are open ditches, and the single lines represent the position and direction of underdrains with their outfalls in the open ditches.

A much larger but similar drainage district, also located in Illinois, where, by a co-operative plan, the open ditches have been dug and the expense apportioned among the landowners in proportion to the benefits derived, has 17·5 miles of main ditch 30 to 60 ft. wide at the top and 8 to 11 ft. deep. Leading into these main ditches there are five laterals 30 ft. wide at the top and 7 to 9 ft. deep, the whole system embracing 70 miles of open ditch, excavated for the express purpose of providing outlets for underdrains, as illustrated in fig. 15.

As an illustration of combined irrigation and drainage in a district subject to tidal flooding in South Carolina, and designed originally for rice culture, figs 16 and 17 convey a general idea of the plan as there adopted. In this district the salt water of the incoming tide holds back the outflowing fresh water in the streams, causing the latter to rise, so that by opening trunk gates whenever desired the water from the streams may be let in upon the fields to any desired extent, and either retained there, or allowed to drain away through the open ditches indicated by the thin lines in fig. 16, the main ditches being shown between the heavy lines.

Fig. 16.—System of flooding and drainage as practised on rice fields in South Carolina.

Fig. 17 is a large section of the general rice field district in South Carolina, of which the preceding figure represents more in detail the method of draining and irrigation.

In the digging of large drainage ditches, various forms of excavators have been devised and are in use, operated usually by steam power and propelled by different devices. In fig. 18 is represented one of the drag boat dredges, which is propelled along the bottom of the ditch upon its own flat base, and is designed especially for small ditches where there is no water. The dredge is moved forward by wire cable playing through sheaves anchored forward, and operated by a drum on the dredge driven by the engine. On account of the large resistance to propelling such a dredge, it is adapted to the use of dippers having less than a cubic yard capacity.

A form of scraper dredge, represented in fig. 19, is propelled along rails or tracks laid on each bank of the ditch, and can be worked either forward or backward. By beginning at the outlet and working forward, the ground is more or less drained, if wet, as the work progresses, which is an advantage in hardening the ground, making the progress less difficult.

Where water is available for floating the dredge along the drainage ditches, one of the floating types has advantages on account of the greater freedom of motion, and fig. 20 represents a sectional view of one of these.

Closed or Under Drains.—When it comes to controlling the excess rainfall of fields, there is little doubt that the final solution of the problem is reached by a proper use of underdrains; and through the invention of the cylindrical clay drain tile, and of the economic methods for their manufacture, the ideal type of drain has

been realized. It only remains to reduce the cost of their proper installation in the field.

Of the many forms or kinds of closed drains

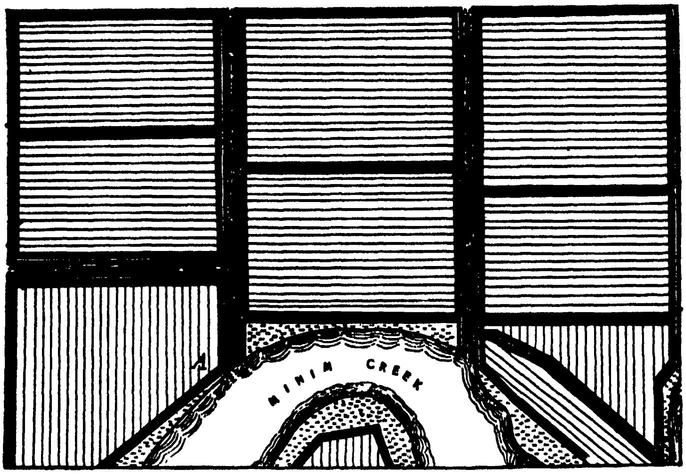


Fig 17.—Section of rice fields in South Carolina (U.S Coast and Geodetic Survey).

used prior to the cylindrical tile, and which are still in use to a limited extent where men of small means are compelled to solve their problems of the day as best they can, using what

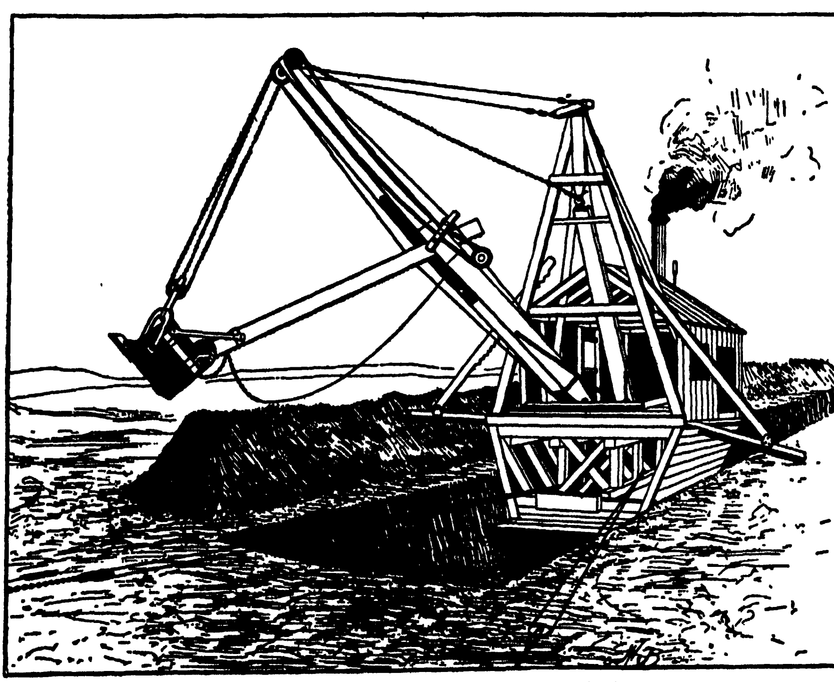


Fig. 18.—Drag boat dredge for cutting dry land ditches.

materials may be at hand, none of these can compete in first cost with the modern tile if a factory is near and labour is counted at its market value. The earth or clay drain, made in place in the field where it is desired, and of the soil itself, is closest to nature, simplest in construction, and could it have been given the character of permanence it would have been the final solution for underdrains. But earth drains could only be temporarily successful even in the very stiffest clay subsoil. They have been made in such soils by digging a ditch to the desired depth, removing with a narrower spade, below the bottom, material which left the drain proper, the space being covered either with sod, turf side down, resting on a shoulder, or by compacting the stiff clay over a flexible core or form which could be drawn forward in the ditch as the work progressed. Many efforts were made to invent an implement, such as that known as the mole plough, which could be drawn by power through the soil at the desired depth, thus forming a continuous channel in the subsoil by simply setting it aside as the result of compression; but channels so made were always very soon either entirely obliterated, or so soon choked at many points as to be of little value.

In other cases open ditches were dug and

on their bottoms were laid, one after another, bundles or fascines composed of twigs, and the earth removed then filled in above them, with the expectation that water would be able to make its way among the members forming the bundles. A more open waterway was secured by placing short sticks in the form of an X, with their ends resting against the sides and on the bottom at regular and short intervals, and in the crotch of these placing fascines made of twigs, or even straw of rice, rye, or wheat, so that when the earth which had been

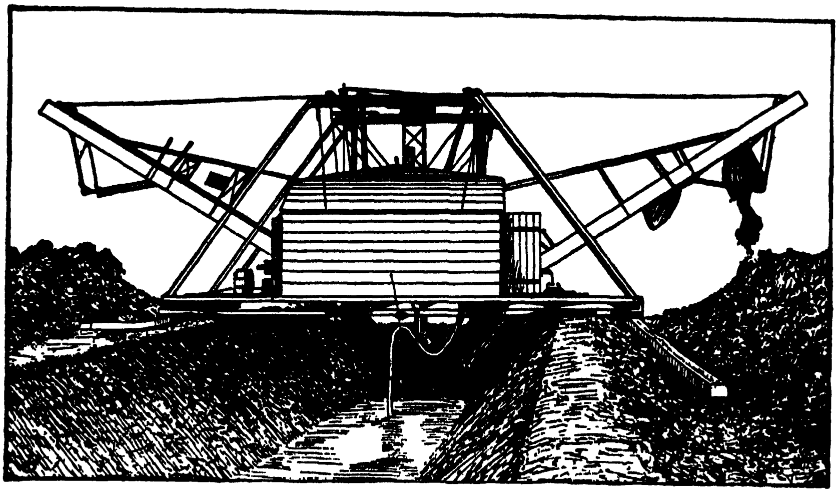


Fig. 19.—Front view of a type of scraper dredge moving on rails laid on banks of ditch.

removed was returned, a V-shaped channel was left through which water could flow with much more freedom; but experience showed that the life of such drains rarely extended beyond eight years, although accounts are found where, with the use of bundles of alder, a much longer service was attained. Round poles, either whole or split in half, have been laid side by side, or a third one on the top of two, and these covered in to form continuous closed drains. In other cases wood was split into 'shakes', as shingles were made in olden time, but thicker and wider,

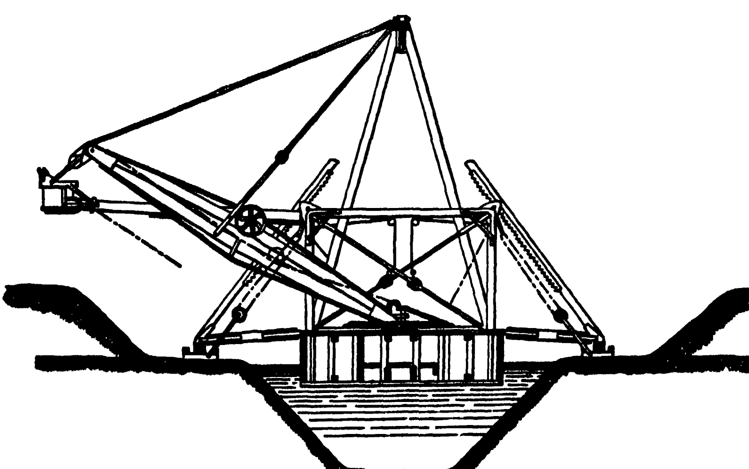


Fig 20.—End view of dipper dredge.

and these set V-shaped on the bottom of the ditch and covered.

So, too, stones have been used in various ways to form different kinds of stone drains. The most common method was to fill the bottom of the ditch to the desired height with small irregular field stones or with larger ones broken into pieces, covering these first with sod or litter, and finally filling the trench with the earth removed. Where flat stones were available these were set to form V-shaped conduits, with the vertex sometimes up and sometimes down, and roofed or paved with other flat stones; or the drains were made with parallel sides. When

great care was exercised in the construction of such drains they were efficient and fairly permanent, but expensive and laborious to build, especially if plenty of stones were not immediately at hand.

Where peat marshes were to be drained the peat itself has sometimes been used, cutting it into blocks with a slicing tool which left a semicylindrical groove on one side of the block and its counterpart on the other, so that when the blocks were dried and their faces placed together in the reverse order from what they were cut, a hollow block was formed which, when laid end to end, gave a continuous waterway capable of rendering service for a number of years.

The makeshift character of all of these types of drains, more than anything else, led to the practice of shallow underdraining, as the works were not sufficiently permanent to warrant the increased expense of greater depth; besides, it was found that after such systems of underdrains had become inefficient, as they soon did, a smaller number of similar drains, laid transverse to the former lines, could be made to connect with those previously laid, and which had become clogged in isolated places, in such a way as to bring them into service again by allowing the water to zigzag back and forth, thus escaping the obstructions. At the present time, however, the occasions should be few where the adoption of any of these earlier methods of forming underdrains may be called into service, unless it might be in the reclamation of some peat marshes, where peat, fascine, or pole drains, because material for such is at hand, might be used to bridge over the period required for the peat to undergo consolidation and subsidence of the surface, which would be likely to render any permanent system of underdrains inefficient by leaving them too shallow.

Best Depth for Underdrains.—In arid soils, where for centuries there has been no waterlogging and always ample underdrainage, there has come to be little or no distinction, such as is found universally in humid climates, between soil and subsoil. The result is, arid and semiarid soils are much more deeply available to crops, and are relatively more productive when brought into good moisture condition, because they are deeper. The 'back furrows', which in humid soils have the effect of simply deepening the surface soil by overplacement, are invariably more productive than the rest of the field, while the 'dead furrows', over which the soil has been rendered thin, are for this reason less so, and this wellnigh universal experience in humid soils should be a perpetual demonstration to every practical man that depth of soil is a necessary factor of high productivity. Everywhere is it true that the soils recognized as being highly fertile are at the same time those which are unusually deep; but deep and adequate underdrainage is the first essential to developing in subsoils the true essential soil qualities, and hence there is little possibility of placing underdrains too deeply in soils of any type if only they are laid in lines sufficiently near to secure adequate drainage. It has been thought that stiff clay soils must be drained less deeply than other types; but the facts are, they need to be drained most deeply of all. The mistake oftenest made with clay soils is to place the underdrains relatively deep but in lines too far apart to render effective service, and to attribute the failure to too deep laying of the drains, and further assume that if they had been laid nearer the surface the drainage would have been better. The basis in observation which has led to this reasoning is the fact that generally when drains are laid shallow it is understood that they must be laid closer together, and it is because drains are laid closer together, rather than because they are laid shallow, that better results have been secured from shallow draining on the stiff, deep clay soils.

It is true that the stiff clay soils do not respond to underdrainage as quickly as other types do, and it is also true that such soils may respond to shallow draining more quickly than to deep drainage, provided the lines are laid close together. This indeed must be expected, but not because deep drainage is undesirable; rather because only a shallow depth, in such heavy insufficiently drained soils, is in condition to respond at once to drainage, and because the improvement needed for such soils is not so much a reduction of the absolute water content in them as it is a change of texture in the subsoil, which follows underdrainage as a necessary result of it, and which later permits the drainage to be rapid and efficient. There will be cases in which, for topographic, physical, or financial reasons, it will be best to have underdrains laid at less than 4 ft., but there certainly are very few, if indeed any, fields or soils requiring supplemental underdrainage in which the productive capacity could not be made higher with underdrains laid more rather than less than 4 ft.

In the case of open-textured subsoils in which the ground water naturally falls to a depth of 5 to 6 ft. or more as early as the middle of the growing season, underdrains may advantageously be laid at depths of 3 ft. Where the third, fourth, and fifth feet of subsoil are close in texture, and are underlaid by a stratum much more permeable to water, the underdrains should be placed in the more permeable stratum. If the surface 2 to 4 ft. of soil is open and underlaid by a deep and very impervious clay, it is still important to place the drains at the proper depth, even if it must be in the impervious stratum; but when this is the case the trench should be entirely filled with the soil of coarser texture, as then full advantage can be taken of the entire zone of porous soil for lateral flow, while at the same time opportunity will have been provided for effecting textural changes in the upper surface of the more impervious stratum, thereby increasing the effective depth of the root zone, which must render the field more productive.

The Approach and Entrance of Water to Underdrains.—The movements of water through soil to enter natural or artificial drainage channels are extremely difficult to forecast, even with the roughest approximation, because the water-

courses in the soil are extremely irregular, not only in their dimensions and directions, but in permanency as well. The porosity of a soil changes both in absolute volume and in extent of subdivision with management, with the season, and with the intensity and character of biological processes taking place. In so far as the flow is through capillary passages, the rate of discharge is directly proportional to the depth of the water above the outlet, and inversely proportional to the distance traversed in reaching the underdrains. The flow also increases with the squares of the effective diameters of the soil grains, and is more rapid as the soil temperature increases.

Again, the flow varies with the amount of pore space in the soil. Thus in the case of sands having the same effective size of grain, but packed so as to possess different porosities, the rates of capillary flow, under otherwise like conditions, vary with the pore space, as represented in the table.

Table showing the effect of varying pore space on capillary flow of water through sands of the same effective size of grain.

Per cent of Pore Space.		Relative Flow.
30	....	100
32	....	123·4
34	....	150·6
36	....	181·5
38	....	217·3
40	..	258·0

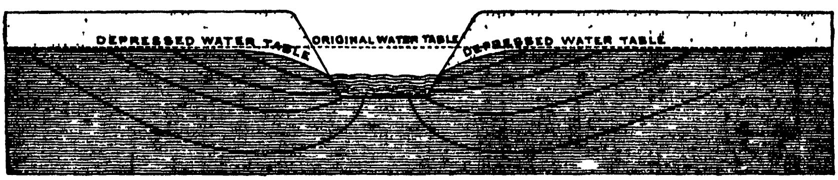


Fig 21.—Showing lines of flow into a drainage ditch, and the shape of the water table. The head under which flow takes place is the difference in height between the original water table and the level of the surface of the water in the ditch. The curved lines show the course taken by water draining through the soil. (After Slichter.)

If the distance traversed through a given soil, in passing from the surface to the underdrain, is doubled, the amount of flow per unit of section is diminished one half. If the effective diameters of soil grains vary as 1 to 4, then the relative rates of capillary flow will differ as 1 to 16. But soils always possess so many passageways for the movement of water which are larger than capillary, and it is so difficult to determine the mean pore space and the mean effective size of soil grains, that although the laws of capillary flow and constants for porous media are fairly well understood, it is not yet possible to use these in laying out drainage systems.

Taking the rate of flow of water through a given soil having a temperature of 32° F. as a basis of comparison, the rates of flow at different temperatures would vary, as in the next table.

Table showing the influence of temperature on the rate of capillary flow.

Temperature. Degrees F.		Relative Flow.	Temperature. Degrees F.		Relative Flow.
32	..	100	70	...	181
40	..	115	80	...	204
50	...	135	90	...	230
60	...	157	100	...	256

In fig. 21 are represented the theoretical lines of flow for water approaching a drainage ditch or a closed underdrain, which makes clear the varying distances through which different portions of the soil water must travel in passing from the surface on its way to the provided outlet, in the case where the field is deeply underlaid by a porous stratum.

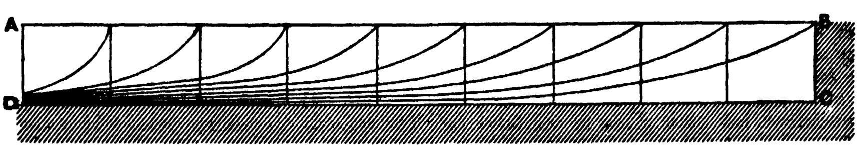


Fig. 22.—Showing seepage lines through a pervious bed overlying an impervious stratum. The curved lines show paths along which seepage takes place. (After Slichter.)

In the case where an impervious stratum underlies the surface soil the lines of flow become concentrated along the bottom of the open soil zone, as represented in fig. 22; while in fig. 23 is illustrated the general law of capillary seepage as the flow varies in direction and in velocity at different depths and distances from the outlet where the soil is underlaid by an impervious stratum.

When the surface soil is close in texture, and is underlaid by a relatively much more open stratum of sand or gravel, the seepage becomes more nearly as represented in fig. 24, the water travelling to the drains chiefly through the porous stratum and entering them from below. But in nearly all soils most of the water enters underdrains from their bottoms, and so largely through the joints that the porosity of the walls themselves is not a matter of importance so far as providing opportunity for the reception of water. Measurements have shown, for an ordinary porous 2-in. drain tile, that seepage into it may take place through the pores in the wall at the rate of 8·1 cu. ft. per 24 hours, and per

100 running ft. of tile when the head was 23·5 in.

Distance between Underdrains. — From the statements just made, it follows that to determine the best distance between underdrains when they are laid in parallel for a given field is a difficult matter. Beside the practical difficulties in determining beforehand the rates of seepage into underdrains, the character, amount, and season at which rain falls must be considered,

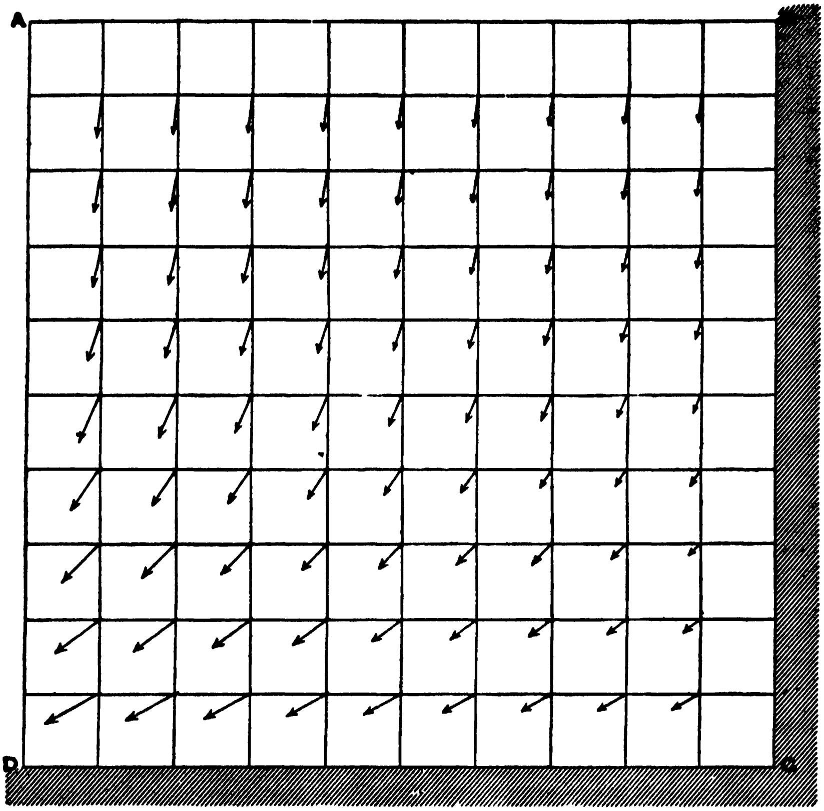


Fig 23 —Showing the direction and rate of seepage in a pervious bed resting upon an impervious floor. The directions and lengths of the arrows show respectively the directions and velocity of motion at various points in the pervious bed. (After Slichter.)

together with what may be called the reservoir capacity of the soil. The ability of the surface 4 ft. to store water in eight quite different soil types, over and above that required for good crop conditions, has been given in the table on page 185, and the smallest capacity there shown is equivalent to 3·61 in. of rainfall, the largest being over 13 in. The corresponding capacity for the four sands represented in fig. 11 was 5·31 for the finest and 12·81 for the coarsest. The rainfall conditions under which the average reservoir capacities in the eight soil types were

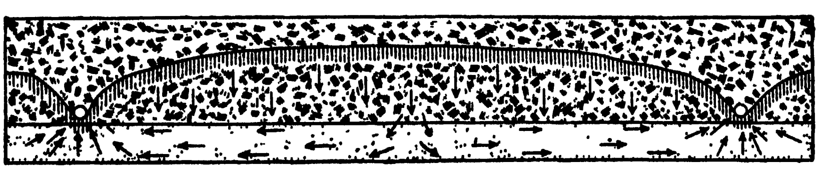


Fig. 24.—Showing how the main flow of water to underdrains may be through a subsoil of sand when this is present near the surface, underlying a closer textured soil.

maintained during the growing season are given in the next table.

The heaviest rainfall during any consecutive ten days was 4·44 in., and that for any single day was 2·52 in.; there was therefore not sufficient rainfall to completely fill the available space in any one of these soils, although double the amount of the highest rainfall in 24 hours would have surpassed the available capacity in two of them, and nearly equalled that in the third.

Rainfalls of 2 in. in 24 hours are not of very

Table showing the lightest rainfall and the heaviest rainfall for one day, and the total rainfall at the four stations for each 10-day period from April 24 to September 10, inclusive, 1908.

[Rainfall in inches.]

Period.	Date.	Goldsboro, N C.			Marlboro, Md.			Lancaster, Pa.			Janesville, Wis.		
		Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.	Lightest rainfall in period.	Heaviest rainfall in period.	Total rainfall of period.
1	April 24 to May 3 ...	·40	0·85	1·25	·07	0·08	0·15	·20	0·20	0·20	0·05	0·09	0·14
2	May 4 to 13	·21	0·21	0·21	·00	0·00	0·00	·00	0·00	0·00	0·13	0·17	0·30
3	May 14 to 23	·08	0·08	0·08	·17	0·42	0·59	·04	0·16	0·20	0·13	0·19	0·32
4	May 24 to June 2 ...	·73	0·83	1·56	·05	0·45	1·23	·05	0·23	0·36	0·07	1·43	3·10
5	June 3 to 12	·03	1·13	2·59	·01	2·01	2·79	·09	2·11	3·04	0·25	0·25	0·25
6	June 13 to 22	·05	0·30	0·35	·02	1·46	3·01	·05	0·55	1·68	0·04	0·05	0·09
7	June 23 to July 2 ...	·11	1·85	3·41	·08	0·39	0·73	·01	0·60	0.94	0·02	1·29	1·47
8	July 3 to 12	·02	0·88	0·95	·08	1·44	2·31	·01	1·03	2·29	0·21	1·22	3·26
9	July 13 to 22	·05	1·59	1·64	·01	2·00	4·44	·01	1·44	1·54	1·62	1·62	1·62
10	July 23 to August 1 .	·20	1·26	2·30	·04	0·24	0·47	·01	0·11	0·12	0·26	0·35	0·61
11	August 2 to 11 ...	·01	1·12	1·50	·01	0·45	1·28	·03	1·10	2·50	0·25	.0·85	1·40
12	August 12 to 21 ...	·07	1·06	2·36	·02	0·47	1·05	·08	0·56	0·95	1·70	1·70	1·70
13	August 22 to 31 ...	·07	0·18	0·38	·04	0·86	1·65	·01	2·52	3·84	0·16	1·62	2·48
14	September 1 to 10 ...	·24	0·62	0·86	·08	0·08	0·08	·01	0·43	1·21	0·18	1·50	2·01
	Total	—	—	19·44	—	—	19·78	—	—	18·87	—	—	18·75
	Longest period without rain.	7 days (July 20 to 26).			7 days (August 20 to 26).			9 days (July 20 to 28).			10 days (July 18 to 27).		

frequent occurrence in most temperate climates, and it is very seldom that one of 5 in. is experienced. Moreover, when the soil becomes filled with water the rate of discharge into underdrains is much increased, because of the greater pressure resulting from the soil being filled to a greater depth. With drains laid at 4 ft. and the soil full of water, the head may become nearly 4 ft., whereas before the rain it may have been even less than 1, and hence the rate of seepage may thus have been increased threefold or more; and as the amount of discharge into underdrains which takes place during a rainfall diminishes by so much the effect of the rainfall in filling the soil, more than the computed amounts of rain would be required to fill the available space indicated in the table on p. 185.

The heaviest rainfall during ten consecutive days which fell upon any one of the eight soil types being considered was 4·44 in., hence a mean rate of seepage into the drains of ·444 in. per 24 hours would have removed the entire rainfall; but even with no surface drainage the amount requiring removal would be less than this by the amounts of water lost from the soil by surface evaporation and through transpiration by the crop. The loss of water by transpiration from most crops becomes so large by the time the crop is one-third matured, that in all ordinary seasons the rainfall will be fully taken care of independently of the drains. Attention must be directed chiefly, therefore, to the removal of surplus water before and during the early part of the growing season.

There are few soils in good physical condition in which drains do not work during the winter, even if the ground freezes deeply. The conditions are such, however, in winter climates, as generally to tend to leave the soil in the spring, throughout the depth of the frozen zone, rather heavily charged with water, not only from the percolation from melting snows, but because of a strong internal evaporation of moisture from the deeper and warmer soil, and the condensation of this by freezing in the cold stratum above. In the early spring, therefore, of cold climates, it is usual to find the soil charged with water above rather than below the optimum condition for crops, and hence demanding a specially rapid drainage. If freezing has been deep, however, the soil to this depth, on account of expansion due to the forming of ice, will have been rendered more open and therefore more quickly drained, especially in the immediate vicinity of good underdrains; but on the other hand the freezing will hardly be deep enough to render more open the soil stratum through which most of the seepage must take place. Besides, there is no time of the year when rapid and complete drainage is more important than the time when the frost has just left the ground. If drainage is made adequate at this time, it is likely to be sufficient for all other portions of the year.

The problem is simplified somewhat by the fact that there is scarcely a possibility of injuring a field by too thorough underdrainage. The Janesville and Miami loams referred to in the table on p. 185 possess a thickness of soil and subsoil scarcely more than 5 to 10 ft. in depth, and under this is a continuous bed of very coarse gravel, with the ground water 60 to 100 ft. below the surface during the entire year. Only a coarse sandy subsoil instead of the rather close clay could make this drainage more complete, but as it is, it is never too much, hence the practical

question resolves itself into: What is the greatest distance at which drains may be laid and yet secure sufficient underdrainage?

Underdrains laid 20 ft. apart, which is twice the depth of the soil and subsoil of the Janesville loam, even if placed 10 ft. deep could not be expected to drain the soil as quickly as in the case cited, but it might drain it quite as thoroughly, for the reason that it is possible that in these loams all surplus water drains away in materially less time than is required for complete drainage.

A lysimeter 12·7 ft. wide, 72·7 ft. long, filled with 5·17 ft. of a sandy glacial till composed of grains having an effective diameter of ·042 mm., and covered with 1·29 ft. of sand, making a depth of 6·464 ft., had in its bottom a centre 3-in. drain with 3-in. laterals on each side every 4 ft. Thus conditioned, when the surface of this lysimeter was maintained under 3 in. of water during 15 days, the rate of seepage into the tile drains amounted to an average of 4·25 in. in 24 hours where the effective head was 6·714 ft. and when the temperature of the escaping water was 14·3° C. This may be taken as a rate much above the maximum which could be attained under field drainage where the tiles are laid 12·7 ft. apart and 6·7 ft. deep, and yet it disposed of but 4·25 in. of water in 24 hours.

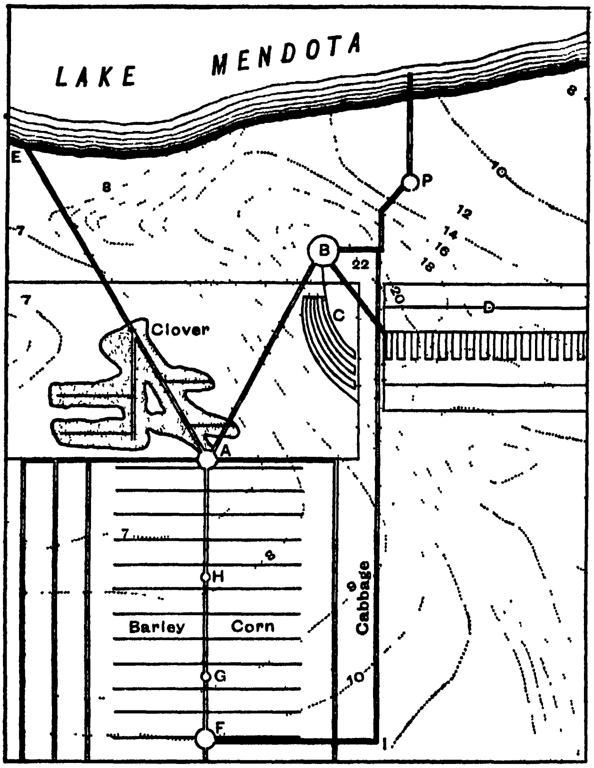


Fig 25.—Showing three systems of 3-in tile drain, E, A, H, G; C; and D, in which the rates of outward seepage of water into the soil were measured In C and D lines of tiles are nearly horizontal, and water communicates by zigzagging in C and from the ends in D

In another series of measurements in undisturbed field soil, where water was pumped into three different systems of 3-in. cylindrical drains, the outward seepage from the drains into the soil was found to be at the rate of 5 gal. of water per 100 linear ft. of tile per minute from the system designated E, A, H, G (fig. 25); at the rate of 10·79 gal. from Series C; and 5·98 gal. per 100 ft. of tile per minute in the case of Series D. The drains in Series E, A, H, G lay 4 ft. beneath the surface in a sandy subsoil, with the ground water, to begin with, but little above the level of the tile, and the water was maintained in silt well A at the level of the ground at that place. In Series C the tiles were placed with their bottoms 18 in. below the surface in a gravelly clay subsoil, changing to a gravelly sand at 3 to 4 ft., and the water pressure was maintained at about the ground surface, or 18 in. above the bottom of the tiles. In Series D the tiles were placed as in Series C, with their bottoms 18 in. below the surface, and with the water level maintained throughout the system at about the ground level.

It is certain that the rates at which water was observed to leave these drain tiles were more rapid than the reverse movement could have been with the soils completely saturated with water and so maintained. If we use the observed rates of outward seepage as a basis for computation, assuming that water might enter the tile drains in the reverse order at the observed rate, the number of inches of water as rainfall which would be removed by the underdrains laid parallel and different distances apart is expressed in the next table.

Table showing computed rainfall which could be removed in 24 hours by drains laid different distances apart, assuming water to enter them at the rates of 5 gal., 5·89, and 10 79 gal. per 100 ft. per minute.

Distances between drains	Series E, A, H, G	Series C	Series D.
feet.	inches.	inches	inches.
20	5·77	6·91	12·46
30	3·85	4·60	8·31
40	2·89	3·45	6·23
50	2·31	2·76	4·98
60	1·93	2·30	4·15
70	1·65	1·97	3·56
80	1·44	1·73	3·12
90	1·28	1·53	2·77
100	1·16	1·38	2·49
150	0·77	0·92	1·66
200	0·69	0·69	1·25

It appears from this table that in the case of the most rapid seepage, and with underdrains 20 ft. apart, a rainfall of 12·46 in. could be

removed in 24 hours. At the slowest rate, and with drains 20 ft. apart, a rainfall of 5·77 in. could be removed in the same time. With drains 70 ft. apart, and the slowest observed rate of seepage, 24 hours would be required to remove 1·65 in. of rainfall; and with drains 150 ft. apart, the most rapid observed rate of seepage would be able to remove but 1·66 in. in 24 hours. Taking the rate of seepage observed in the case of the lysimeter, 2·70 in. would be removed in the case where the drains are 20 ft. apart during 24 hours; 1·35 in. when the drains are 40 ft. apart; ·90 in. when the drains are 60 ft. apart, and ·54 in. with the drains 100 ft. apart during 24 hours.

Practical experience appears to indicate that for depths of 2·5 to 4 ft., and with rather open sandy subsoil, drains may be laid at distances of 60 to 75 ft.; where the subsoil is sandy mixed with clay, the distances must be reduced to from 30 to 50 ft.; for clayey subsoils with interstratified layers of sand, distances must be reduced to from 22 to 27 ft., and for the stiffest clay subsoils thorough drainage can hardly be secured with distances between underdrains greater than 15 to 20 ft. In the United States much land is drained with the lines ranging from 75 to 150, and even 200 ft., but these cases are for the flat lands, where only the local rainfall must be removed, and where there is a deep, open, sandy subsoil in which the underdrains can be laid. Few drains are laid closer than 25 to 30 ft., unless exceptionally thorough drainage is sought.

In practice, the cost of installing thorough underdrainage has always had much to do in determining the distances apart at which drains have been laid, and often has led to unsatisfactory final results. Because the cost increases rapidly, both with the depth and with the nearness of drains together, it requires careful and wise discrimination in determining the best course to pursue under different conditions, and the advice of experienced and trusted counsel should be sought and employed whenever available. It is very important to keep in mind in this connection, that drains laid too shallow do not permit the field to be developed so as to possess the highest productive power attainable, and that when the drains are placed too far apart the same is also true.

Size of Tile and Length of Drains.—Practical experience in drainage leads more and more to the discouragement of the use of tiles of small diameter, even as laterals, and this is most emphatically true wherever the fall is slight. In the United States few tiles are now made having a less diameter than 3 in. Those under 8 in. in diameter are either 12 or 14 in. long, and the larger sizes 24 to 28 in., weighing from 7 to 8 lbs. for the smallest size and shortest length, to 64 to 74 lbs. for the largest size and greater length. The difficulty in securing men skilled in shaping the bottom of the ditch and in laying the tiles true to grade, who at the same time are thoroughly trustworthy, makes it quite unsafe to try to lay tiles less than 3 in. in diameter. Besides, even when the work is well done, the amount of friction is relatively so large, and the tendency to clog so great, with the smaller sizes, that when permanency is taken into account the comparatively small saving in cost on the tile hardly justifies the greater risk of having the work to do over in a comparatively few years. It is often necessary in draining to lay laterals with very little or even no fall, and when this is the case it is extremely important that tiles of the larger diameters be used.

The manner in which water enters laterals, along their entire length, makes the computation of the capacity of drains more complicated and more uncertain than is the case with city sewers or with water mains, but various formulæ have been devised for the use of land drainage engineers. If, for example, 1000 ft. of drain lies in a saturated soil, and there is uniform seepage into it throughout its entire length, the section nearest the outlet must carry, in addition to that which enters it from the soil, the whole of that which has been gathered by the members above it, and hence the drain will run less and less nearly full as the distance from its outlet increases; but it is neither practicable nor desirable to adapt closely the sizes of tile in laterals to the amount of water they must carry, 4-in. and 3-in. tile only being used, with possibly 2-in. sizes where the fall is strong, constituting the end sections or where the laterals are short.

The relation of the diameter, length, and fall of a drain to the amount of water it is capable of discharging may be computed with the aid of formulæ, one of which is that of Poncelet, given below:—

$$\text{Velocity of discharge, } V = 48\sqrt{\frac{df}{l + 54d}}$$

$$\text{Quantity of discharge, } Q = 48a\sqrt{\frac{df}{l + 54d}}$$

Where V = velocity of discharge in feet per second,
d = diameter of drain in feet,
f = total fall of drain in feet,
a = area of cross section of drain,
Q = discharge in cubic feet per second.

In the next table are given the computed distances apart at which drains of three sizes may be laid to remove 1 in. of rainfall in 24 hours, so that the carrying capacity may be taxed to its limit under the head due to the fall alone, and supposing that the soil is in condition to permit the water to seep into the drains at the necessary rate.

The table on p. 204 indicates that a 2-in. drain 500 ft. long, and with a fall of 6 in. per 100 ft., would run full at its lower end in removing 1 in of rainfall in 24 hours when the distance between the laterals is 62 ft. To remove water at this rate it must enter the drain at a mean rate of 2·68 gal. per minute per 100 ft. in length, and this is about half the lowest observed rate of outward seepage given in the table on page 202. But with a fall of only ·6 in. in 100 ft., water entering the drain at about ·9 gal. per minute per 100 ft. would give the drain its full load with the laterals 19 ft. apart. A rainfall of 1 in. during 24 hours, however, may well be given somewhat more than this time for its removal, perhaps even double, without

Table showing the distance between 2-, 3-, and 4-in. drains, 500, 1000, and 2000 feet long, at which the removal of 1 in. of rainfall in 24 hours will fully tax the capacity of the drains under a head due to the fall alone.

Fall per 100 ft.		500 ft. 2-in. tile.		1000 ft. 3-in. tile.		2000 ft. 4-in. tile.	
		Distance apart.	Discharge per minute.	Distance apart.	Discharge per minute.	Distance apart.	Discharge per minute.
per cent.	inches.	feet.	cu. ft.	feet.	cu. ft.	feet.	cu. ft.
·50	6·0	62	1·79	85	4·97	88	10·22
·25	3·0	43	1·28	60	3·51	62	7·22
·20	2·4	39	1·13	54	3·14	55	6·46
·15	1·8	34	0·98	49	2·76	48	5·60
·10	1·2	27	0·80	38	2·22	39	4·57
·05	0·6	19	0·57	27	1·57	28	3·23

serious results. Elliott's judgment, however, as expressed in the following table, is that the limit of grade and of length for a 2-in. drain is 600 ft., with a minimum fall of 1·2 in. per 100 ft. With a drain of 3 in. in diameter and its length made 1000 ft., for the removal of an inch of rain during 24 hours the computed distance apart of the lines (see above table) is some 85 ft. when the fall is 6 in. in 100 ft. In this case the water would need to enter the drains at the rate of 3·71 gal. per minute per 100 ft., which is also less than the slowest observed outward seepage cited. Elliot places the minimum grade for 3-in. tile at 1·08 in. per 100 ft., and the limit of length at 800 ft.

In the case of a 4-in. drain 2000 ft. long, with a fall of 6 in. per 100 ft., the formula indicates a distance between drains, as given in the above table, of 88 ft., and with a fall of ·6 in. a distance apart of 28 ft., for the removal of 1 in. of rainfall during 24 hours. In this case water would require to enter the drain at the mean rate of 3·82 and 1·3 gal. per minute respectively per 100 ft., and the largest rate here is less than the smallest cited for the observed outward seepage. The next table places the minimum grade for this size of tile at ·6 in. per 100 ft., and the limit of length at 1600 ft.

Limit of size of tile to grade and length (Elliott).

Size of Tile in inches.	Minimum Grade in inches.	Limit of Length in feet.
2	1·20	600
3	1·08	800
4	·60	1600
5	·60	2000
6	·60	2500
7	·60	2800
8	·60	3000
9	·60	3500
10	·48	4000
11	·48	4500
12	·48	5300

It is held by some drainage engineers that even where thorough drainage is practised, drains do not remove ½ in. of water in 24 hours, and that if ⅛ in. per day is removed this is sufficient for general practice, and it is quite true that the removal of even ⅛ in. per day, on the average, is the equivalent of 3·75 in. per month, allowing nothing for evaporation. But when drains discharge continuously from October to June, as described by J. Bailey Denton (Journal of the Royal Agricultural Society, page 273, 1859) in the case of drainage systems on the Hinxworth estate during the winter of 1856–7, the fact demonstrates that those fields were continuously and completely saturated with water above the level of some portion of the lines of tile, and therefore that they were not as thoroughly drained as is the case with the majority of upland, highly fertile soils. In the case of Drains 31 and 32, laid 25 ft. apart and 4 ft. deep in what was called a stiff clay, a rainfall of 1·645 in. in October and 1·630 in November, or a total of 3·275 in. in all, was required to saturate the soil and bring the level of the ground water sufficiently high to discharge into the drains. The December rains, amounting to 1·235 in., charged the soil so that the drainage was 20·8 per cent of the rainfall. Between December 30 and January 8, with a rainfall aggregating but ·54 in., the drainage increased to 33·7 per cent of the rainfall, or ·17 in. During the next ten days, with a rainfall of 1·179 in., the discharge from the drains increased to 54·8 per cent of the rainfall, which is a rate of ·065 in. per day. The most rapid discharge from this system of drains occurred in the next interval, and was at the rate of ·227 in. in 24 hours; but a more rapid discharge occurred at the same time from the parallel drains 10, 11, amounting to ·267 in. These rapid discharges were associated with a rainfall of ·54 in. and occurred on the same day, amounting to 44 and 49 per cent respectively of the total rainfall.

The relations between the rainfall, the discharge from the drains, and the changes in level of the ground-water surface midway between the lines of tile 25 ft. apart, and in comparable land not underdrained, are represented graphically in fig. 26. In this figure it will be seen that notwithstanding the nearness of the drains and the comparatively small rainfall, the ground-water surface continued to rise until near the middle of February, when it was within 34 in. of the surface between the drains, and within 1 ft. of the surface in the undrained land. During this interval of rise covering 129 days the total rainfall had been but 6·943 in., or an average of less than ·054 in. per day. Moreover, rain fell on more than half the days, and the heaviest fall on any day was ·54 in. After February 6, with only four days of rain aggregating but ·092 in. until March 8, the ground water fell to the level of the drains only after

the middle of March. From this time on to the end of May the water remained about 4 ft. below the surface on the drained land with a rainfall of 3·01 in., occurring on 41 out of 84 days, ·46 in. being the heaviest rain in any day. It appears, therefore, that under these conditions a mean rainfall of ·054 in. daily maintained the ground-water surface some 18 in. above drains laid 25 ft. apart in such soils, with the drains 4 ft. deep; but that with a mean daily rainfall of ·036 in. thorough drainage to the depth of nearly 4 ft. was secured.

In the case of Fields 18, 19, and 20, with drains laid 4 ft. 7 in. deep and 174 ft. apart in a soil of 'lower chalk mixed with clay, sand, gravel, and coprolites', the drains were only able to remove 62 per cent of the mean daily rainfall of ·057 in., or 3·668 in. out of the total of 5·929 in. falling on 55 out of 104 days between October 1 and January 12, and when the heaviest rainfall on any day was but ·54 in. During this 104 days the ground water rose 43·5 in., to within 2 ft. of the surface of the field midway between the drains. The most rapid observed seepage from these fields during the period was ·0866 in. per day. So, too, in the case of Field 40, Denton's table shows that on March 1 the ground water was still 3 ft. 4 in. above the drains on the upper side of the field, where they had been laid 7 ft. 6 in. deep and 225 ft. apart, and 5·5 in. above on the lower side, where the drains were 99 ft. apart. But by the end of May the ground-water level had fallen to 6 ft. 8 in. below the surface where the drains were 7 ft. 6 in. deep, and to 6·5 in. below the drains where they are closest to-

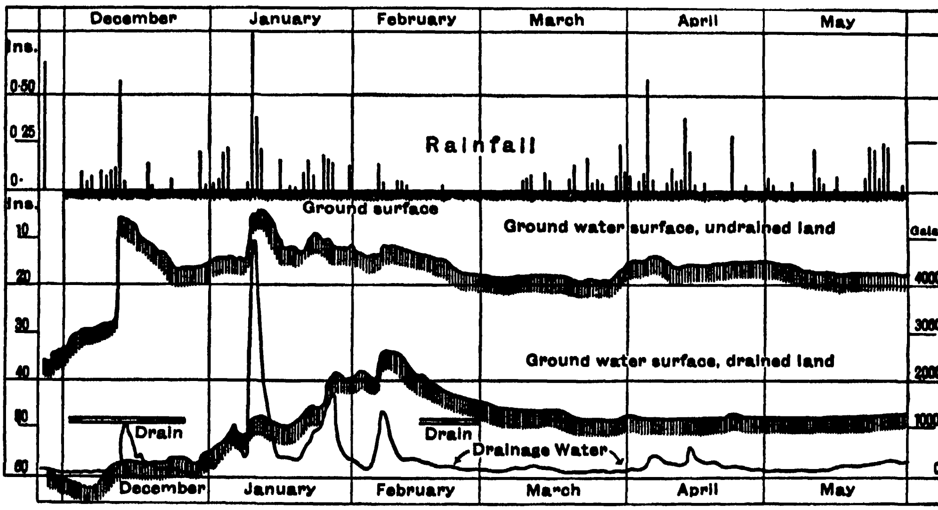


Fig. 26.—Showing the relation of rainfall to the ground-water level between tile drains laid 4 ft deep and 25 ft. apart in a clay soil. The upper portion of the figure shows the quantity and distribution of rain. The shaded curves show the variations in level of the ground-water surface, and the lowest curve represents the rate of drainage from Nos 31 and 32 Fields on the Hinxworth estate. (From data by J. Bailey Denton in Journal of Royal Agr. Soc., page 278, 1859.)

gether and 6 ft. deep. It appears clear, therefore, that under the conditions of all these fields the drains were unable to fully control a mean daily rainfall of ·057 in. falling between October 1 and January 12, but that they were able to control the lighter rainfall, averaging ·0296 in. daily, falling between January 12 and May 1, when there were 58 out of 139 rainy days, ·46 in. being the heaviest fall.

The observations of Denton here cited and those of the writer, illustrated in figs. 11, 12, and 25, make it clear that water seeps so slowly through soils into underdrains that laterals, so far as capacity merely for carrying water is concerned, need not have large diameters unless they are very long; nevertheless, on account of the difficulty of having them laid so as to remain permanently open, it cannot be regarded a wise practice to lay tiles in laterals smaller than 3 in., possibly 2 in. for terminal sections or where the fall is large. Laterals seldom or never run full, and the water is moved through them only by the head due to grade alone, and this is diminished by friction. This being true, the velocity of flow in the lateral is greatest when it is running three-fourths full, and is as great when running half full as it is when running full. The tendency of the lateral to keep itself clear is therefore greatest when it is neither too small nor too large. With mains and sub-mains the case is different. The slope of the laterals, added to the slope of the sub-mains and mains, may sometimes result in filling the main entirely full so that it flows under a pressure greater than that due to its grade alone, so that during periods of heavy rainfall the velocity in the main may be considerably increased by the pressure thus resulting. The sizes of mains, however, should be so chosen that little pressure will result from this cause, for the reason that, should there be considerable pressure, either outward seepage from the main must result, or it will permit little draining effect of the main upon the land through which it passes; but, more serious still, if laterals enter where the mains run full under pressure,

slack water must result in the laterals themselves, which tends to cause any sediment carried in suspension or being moved along the bottom of the drain to be deposited, thus tending to clog the lateral back of its junction with the main.

A practical illustration of the sizes and distances apart of drains, as laid in the United States, in a very flat section where the soil is a rich black loam approaching muck in its lowest places, and at 2·5 ft. is underlaid with a yellow clay subsoil, is represented in fig. 27. The fall of the main is not less than 2 in. in

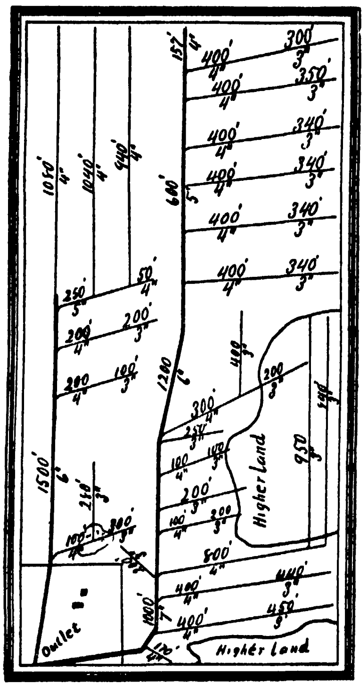


Fig. 27.—Showing size and distances for drains in an 80-ac. field of flat land moderately drained. Double lines are mains, single lines laterals; numbers give length of drains in feet and diameter of tiles in inches. (Laid out by C. G. Elliott, C.E.)

100 ft., that of the laterals being more rather than less. The mains begin with 1000 ft. of 7-in. tile, carrying the water from 80 ac. of flat land surrounded by nearly level fields; next follow 1200 ft. of 6-in., then 600 ft. of 5-in., and closing with 157 ft. of 4-in. tile into which no laterals lead. Nothing smaller than a 3-in. tile is used for laterals, and the least distance between them is about 150 ft.

It should be observed that all lands above tide water, even when flat and apparently not drained, possess a natural, deep underdrainage more or less strongly marked, and always operative, as in naturally well-drained upland. The operation of this type of drainage is shown clearly in fig. 26, where the water level falls below the underdrains. This lowering of the ground water below artificial outlets may be in part due to capillarity and root action during the growing season, but the underdrainage is everywhere present to a greater or less extent, and in so far as it is operative it lessens the work required of underdrains.

Grade and Outlet of Drains.—The grade, slope, or fall of a drain should receive most careful consideration, and unless the fall is considerable, the grade should be accurately determined by suitable levelling instruments and the drains laid accurately to it. It requires much practical experience and skill in the details of construction and laying out to properly take into account the requirements of the soil, the cost, and best size of drains, in order to decide the grade best to adopt in a particular case. It will generally be necessary, in laying out both mains and laterals, to secure the greatest fall possible. The shortest and straightest drain is generally best, but in order to secure this result the mains must be laid along the lowest axes in the field, and there are but few areas requiring drainage which do not possess some low-lying stretch along which surface water generally flows, and it is usually along these courses that mains and sub-mains are most advantageously placed, avoiding as far as possible tortuous deviations, without interfering with the proper approach of necessary laterals.

Laterals should be laid along the line of steepest slope, and it is very important to look closely to this, because in no other way is it possible to secure so effective a fall for the seepage of water into the laterals. It has been the practice to lay lines of drains across the fall or natural slope, but whenever this is done the seepage into the drain from the lower side must be less effective, although there may be a somewhat greater fall and stronger seepage from the opposite side; this is never a full compensation. It will be clear from an inspection of fig. 6, and what has been said relative thereto, that the ground water tends to flow directly across the contours, and down the steepest slopes as there represented. This being the case, there must be a tendency for water, after entering a lateral laid across the slope, to flow out of the drain at the joints on the opposite side from which it entered, and to continue its natural course. But with the drains laid down the slope there can be no tendency to escape, and the drain can be given its greatest fall and highest efficiency. In fig. 28 is represented the manner of laying out a system of mains and laterals as nearly as practicable at right angles to the contour lines, and therefore directly down the steepest slopes. The diagram represents a drainage system in Lower Austria, covering some 50 ac. which rises toward the north-west and west at about a 2-per-cent grade, the dotted contour lines being drawn at intervals of 1 metre (3·28 ft.). The solid black lines represent underdrains, the double line *l d* is a surface ditch (the topography beyond *l* rising somewhat abruptly) which discharges its water into *d g i*, thus preventing it from going over the field. The brook *c d k* has been straightened and made to flow along *c d g i*, the old channel having been filled from *d* to *k*. The underdrains are laid 40 to 50 ft. apart, and 3 ft. 3 in. to 4 ft. 2 in. deep.

It will not always be possible to lay even laterals along continuously straight lines, although this is desirable to save tile, labour, and to avoid loss of head; but when curvatures in the line become necessary they should be made in a gradual curve, such as can be readily given with the ordinary tile, without leaving appreciably open joints on the outside.

While the maximum grade possible should be chosen in most cases, the minimum grade which can be successfully used in tile drainage is a matter for important consideration, as in many cases it will be necessary to adopt very small falls, or even almost none at all except such as can be secured through increasing the size of the tile used. Much land has been successfully drained with falls as low as ½ in. per 100 ft.; in such cases, however, the greatest care must be exercised in laying the tile true to grade and strictly in line, choosing sizes sufficiently large to compensate for the small fall.

A uniform grade for underdrains is the simplest and best to adopt wherever practicable. Where the grade must be changed, as will often happen, to avoid too deep digging, it is best, if possible, to so lay out the line of grade that the water always flows from a section of less to one of greater fall, in order to make sure that sediments carried in the water shall not be deposited.

Where laterals or sub-mains are joined with a main this is best accomplished through the use of Y junctions, which provide that the inflow is at an angle directed downstream, and that it shall enter the main with a certain drop, increasing with the size of the main. Branches leading into 6-in. mains should have a drop of ·2 of a foot, and those leading into 8-, 10-, and 12-in. mains, drops of ·3, ·4, and ·5 respectively, as represented in fig. 29. The Y junctions manufactured at the tile factory are much more satisfactory and safer to use than

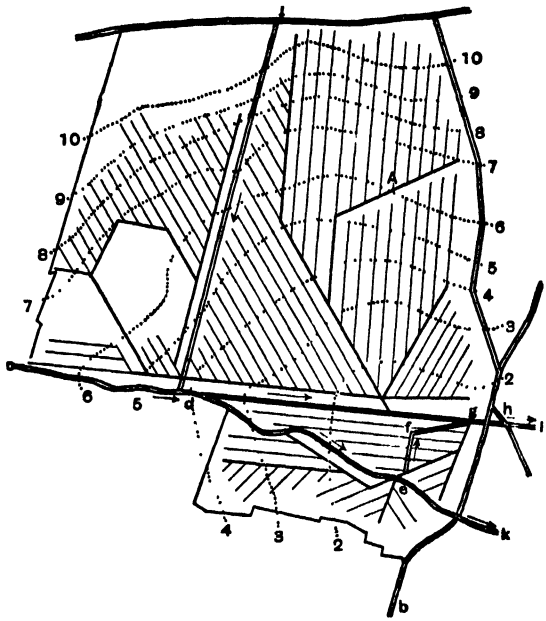


Fig 28.—Showing system of underdrains covering about 50 ac. laid down the steepest slopes or at right angles to contour lines. Dotted lines represent contours at intervals of 1 metre, solid lines represent underdrains; *l d* is a surface ditch; *d g i* is a straightened stream channel to take the place of *d e f g* and *d e k*.

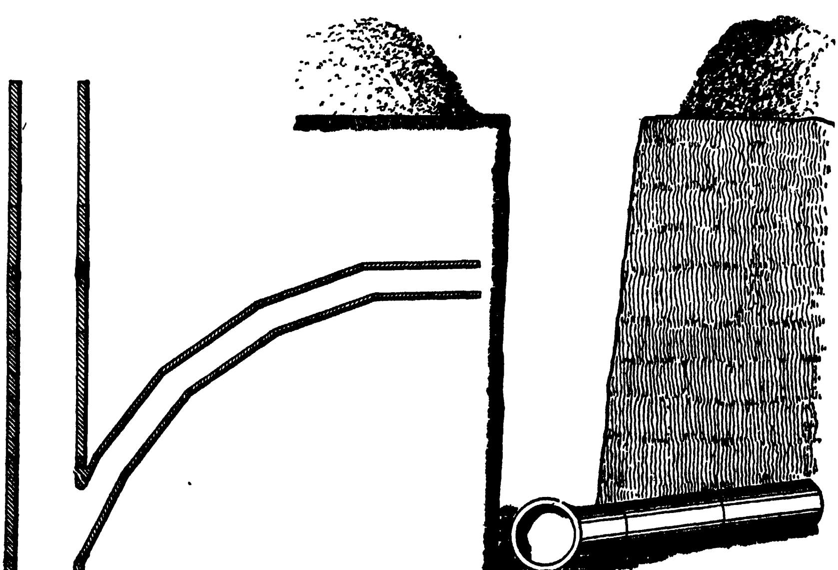


Fig. 29.—Showing Y junction tile and method of connecting lateral with main.

those improvised by chipping with the aid of the tile pick, as much closer unions can be made, which are less liable to displacement.

Where the outlet of a drain is into an open ditch or a stream, some form of protection must be adopted to ensure the outlet against becoming obstructed. Ordinary vitrified drain tiles make very satisfactory terminals, ordinary tiles not answering the purpose for climates where freezing occurs, as the action of the frost causes them to crumble. Where ordinary drain tiles are of the vitrified type these will answer instead of the sewer tile, but in either case there should be not less than 8 to 12 ft. of the frostproof tile used. Another good plan is to bed the last 8 ft. of outlet tile of the ordinary type in rich

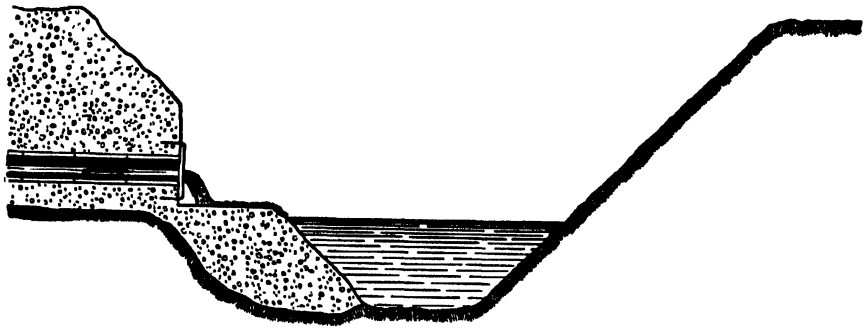


Fig 30 —Showing method of embedding ordinary drain tile in concrete to form opening into ditch.

concrete, as represented in fig. 30, filling the concrete directly into the ditch, building the front up to the level of the ground, carrying it back 2 or 3 ft. from the outlet at the level of

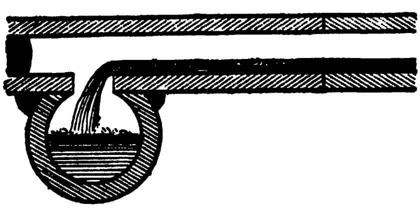


Fig. 31.—Showing method of joining lateral with main by direct downward discharge. (After Kuhn.)

the ground, when it may be allowed to slope backward to the level of the tile at 8 or 10 ft. from the outlet. With this construction no harm would result even if the action of the frost tended to crumble out the ordinary drain tile, as the concrete would constitute and maintain the channel clear.

Such outlets as these should be protected by some type of grating to prevent the entrance of animals. Such grating can be most simply provided by using ⅜ or ½ in. round iron of suitable length, with the two ends bent at a right angle and embedded vertically in the concrete as it is laid, as represented in fig. 30, setting the bars about 1 in. apart. In some cases wooden boxes are provided, 12 to 14 ft. long, made of 2-in. plank, and bedded in the bottom of the ditch at its outlet, the drain opening into and discharging through this. Such an arrangement, however, is not as durable as the concrete.

A German method of joining a lateral with a main is represented in fig. 31, where the lateral is laid directly upon the main with its end closed with a stone and plug of clay, or with a plug of cement, and discharges its contents by a common opening directly downward. Such an arrangement has the disadvantage of being difficult to use where the available fall is small; at the same time it checks the velocity of flow in the main to the same extent that would be the case were the lateral joined at a right angle with the main instead of as represented in fig. 29, with the Y junction.

Where several sub-mains are joined into a single main it has been customary to use the silt basin, represented in fig. 32; but this method, like the last, aside from being more expensive than the Y junctions, cannot well be used except where there is ample fall, because the water entering the basin not only has its velocity checked,

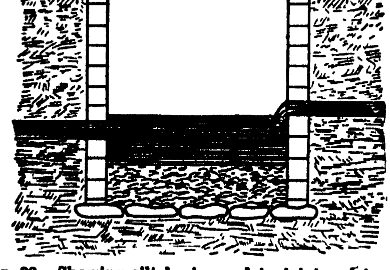


Fig. 32.—Showing silt basin used in joining sub-mains, where grade changes from very steep to one that is small, or where surface water is to be admitted to underdrains.

but requires an additional force to overcome the entrance resistance to the outlet main. In cases where the grade must be changed to one

less steep, and especially if the soil above is open and free-running, so that sediment is liable to be carried, and particularly if the fall below is very small, there is more need of adopting the silt-well method, which allows the sediment to collect at the bottom, from whence it may be removed from time to time. It is sometimes desirable to introduce surface water into underdrains, and where this is the case the silt basin may be used to advantage, as it is never admissible to introduce surface water directly into an underdrain on account of the danger of clogging; but through the instrumentality of the silt basin, the water entering near the top, the sediment may be deposited at the bottom if carried by the water, and the water enter the underdrain clear, or sufficiently so to avoid the danger of clogging.

There are occasional basin-shaped areas needing drainage, but for which no surface outlet by direct gravity can be provided. Some of these

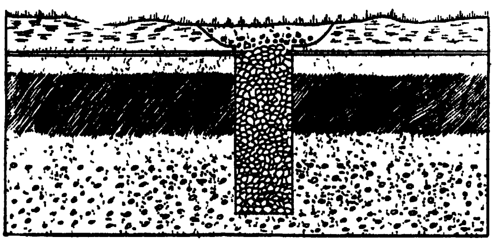


Fig. 33.—Showing method of providing outlet for drains into underlying porous stratum

are underlaid at a few feet by a porous stratum, which would provide natural drainage were it not for the overlying impervious layer of clay which retains the water near the surface. The simplest method of draining such areas, where the impervious stratum is thin, is represented in fig. 33, where a well is dug, extending into the porous stratum, which is then filled with cobblestone or broken rock, covered with coarse gravel and sand, and finally with the soil of the area. Underdrains are laid in the usual way, leading from opposite directions into this sinking basin, the number depending upon the size of the area to be drained and the amount of water to be removed. In order to ensure that no sediment shall be carried into the sinking basin to clog the porous walls, it may be best in some cases to lead the water first into a silt basin which discharges into the sink. If these areas are subject to the accumulation of surface water, provision should be made, as illustrated in fig. 14, to convey this away by means of border surface drains.

It is not possible to say how large an area such a sinking basin may drain, as this must be determined by the porosity of the underlying stratum and the amount of water to be removed. In a direct measurement of such a case, made by the writer, water was admitted to a porous stratum through a column of 5-in. drain tile 13·5 ft. long sunk into the porous stratum, composed of grains whose effective sizes were ·13, ·18, ·17, ·22, ·15, ·11, and ·06 mm. in the 7th to the 13th foot respectively. The ground-water level was at the time at the bottom of the well. Under these conditions, measurements showed that the percolation during four days was at an average rate of 90·9 cu. ft. per 24 hours, which represents about ·25 in. of rainfall on ·1 of an acre removed in 24 hours, or ·025 of an inch per acre in the same time. The capacity of the well decreased as the experiment progressed, although perfectly clear water was used, until the rate at the close was a trifle less than ·01 of an inch of rainfall per acre per 24 hours, and therefore a little less per acre than the mean total drainage from Fields Nos. 31 and 32 of the Hinxworth Estate from November 27 to May 31, referred to on p. 204). During this experiment the water rose but three inches 4 ft. from the well. This principle of underdrainage has been somewhat extensively practised in Holland, where the results have been secured by simply boring vertically into the porous stratum with an auger of suitable size, providing holes into which are set poles, terminating far enough below the surface to be out of the way. The space about these poles is then filled with small stones to the height of the poles, and then with the soil of the field. In some cases the number of borings to secure drainage has been made as great as 12 to 16 per sq. rod.

Submerged outlets for mains are sometimes a necessity, although they should be avoided wherever practicable. When they must be adopted, due allowance should be made, in laying out the grade line for the mains, for the amount by which the outlet may be under water. If there is sufficient velocity of discharge at the outlet to keep the drain clear of sediment, there can be no injury to it, and no objection, except that it must be understood that land adjacent to such an outlet or main cannot be drained quite as low as the level of the water at the outlet. In very flat districts it is not always possible to so lay out a drainage system as to prevent the outlets being submerged at least a portion of the time. But such necessity should not deter the carrying out of drainage improvements if other conditions are such as to warrant it.

Systems of Underdrains.—In laying out the drainage for fields or for districts it is important to secure the best fall practicable for both mains and laterals, the least amount of excavation and filling, and at the same time the smallest outlay for both tiles and outlets consistent with thorough drainage. In order to do this it is usually necessary, unless it be for single fields, to have a survey made, locating important features, like the highest and lowest points, the course of natural surface drainage, and, if the area is large and the surface quite uneven, especially if the falls are not large, a more or less detailed map will be found very helpful, and this should have sketched upon it the differences in elevation at stated intervals by means of contour lines.

Where much of the field requires but little drainage, and possesses only a few low places and swales, as represented in fig. 34, the mains and laterals will be laid out without any definite

system or parallelism, each line being run to or through the area which seems to demand treatment.

Where general drainage is required for an entire area, and this is large, with but a small fall in one direction, while the outlet must be in a stream, or some drainage ditch specially provided, the drains will be laid out as represented in fig. 35, all running parallel, and, if not very close together, with separate outlets.

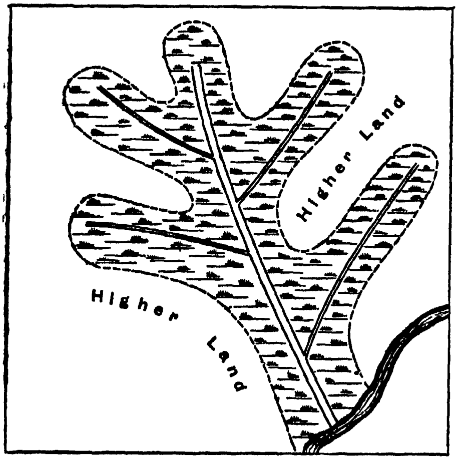


Fig. 34 —System of occasional drains for partial drainage.

If the surface is flat, the slope uniform and in one direction, as just described, but the texture of the soil is closer, so that laterals must be placed but 25 to 40 ft. apart, the number of outlets would be so large that a saving could be effected by collecting the laterals into groups by means of sub-mains, as represented in fig. 36.

If the area to be drained is such as to require long lines of laterals, so that more than one size of tile becomes necessary, a saving may be effected by such a grouping as that represented

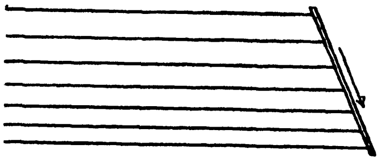


Fig. 35.—Separate line drainage for flat areas with uniform fall.

in fig. 37, B as compared with A, or as represented in fig. 28 at the section A. In the case of fig. 37, representing an area 2000 ft. by 900 ft. above the line *a a*, 9000 ft. of 4-in. and 9000 ft. of 3-in. tile are laid 100 ft. apart in A, while in B only 3000 ft. of the larger size and 15,300 ft. of 3 in. render the same service, with a material saving in the cost of tile.

Where the surface of the area slopes uniformly in one direction, but where the lower portion of the field to be drained is a soil of closer texture, or one which for any other reason requires the drains to be closer together, an arrangement of laterals similar to that represented in either A or B, fig. 38, may be adopted to advantage.

It sometimes happens that a wide swale, slough, or wet hollow, extends through an area requiring drainage, so that two parallel mains,

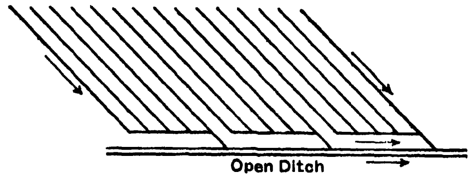


Fig 36.—Grouping laterals to reduce number of outlets.

as represented in fig. 39, may be used to advantage. When this is the case, and the lowest area has a smaller fall in the direction of the laterals, the two mains should be placed as nearly along the line where the grade changes as is practicable, to avoid making a change in the grade of the laterals themselves.

It should be remembered in cases of this sort, that unless the slough represented has comparatively little fall toward its centre, such an arrangement would not be as satisfactory as a single main run along its centre.

Practice of Underdraining.—The best work in underdraining can only be secured through men who have a thorough grasp of the principles of the art, and who have had sufficient practical

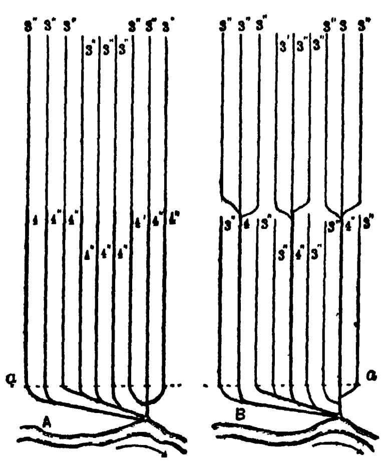


Fig. 37.—Grouping laterals to reduce the number of large tiles.

experience to make them thoroughly familiar with all fundamental details as they vary with soil, topography, climate, and crop conditions.

There are many cases of local drainage, where the area is small and the expense involved not large, and especially where the fall is considerable, that the farmer himself, having a fair knowledge of the principles of drainage, will be able to satisfactorily supervise, or he may do the work himself; but when large areas are to be underdrained, where the fall is small and the surface conditions irregular and complex, it will usually be safest and more economical to en-

trust the levelling and staking out of mains and laterals, ready for the ditcher, to a competent and thoroughly reliable drainage engineer.

Indeed it will generally be best, and more economical, in such cases to let the entire job, especially if it is large and difficult, to a man of experience who has established a reputation for reliable work. Even in the matter of digging the ditch, and particularly in giving it its finish, as well as in placing the tiles and making the initial covering, practical drainage engineers and contractors themselves find it difficult to secure and retain men who have the necessary patience, the feeling of responsibility, and the practical skill to continually do thoroughly reliable work when not under immediate supervision. A man who has the right frame of mind, and the skill to do this finishing and most important work well, is much more to be trusted usually than the farmer himself, who has so many duties to distract his attention and tempt him to hurry the work faster than the best results will warrant.

But while the general farmer should not be encouraged to attempt the draining of large and difficult areas on his own place without expert advice, it is very important that he should possess a clear conception of the general principles underlying good drainage and what constitutes thoroughly satisfactory practice.

It is the duty of the drainage engineer to lay out the lines of drains in the field. Stakes are provided beforehand, and of two kinds: one set of 'finders', 16 to 24 in. long, where weeds and grass are not too high; and the other, 'grade pegs', about 8 in. long. These stakes are set in line, beginning at the outlet or a junction with a main or sub-main, at distances of 100 ft. apart. The 'finders' should be numbered 0, 1, 2, 3, &c., to the end of the line, and should be marked with the depth below the grade peg at that place to which the ditch is to be dug, and any other data which may be needful. The 'finders' are set about 14 in. to one side of the proposed centre line of the ditch, and the grade pegs are driven into the ground with their tops flush with the surface and about 4 in. from the 'finders'. It is from the tops of these that elevations are to be taken for fixing the grade of the ditch, and from which measurements are to be made in setting the grade line and measuring for the depth of the ditch. These stakes should be set in line except where curvatures in the ditch are intended.

After the stakes have been set, the levels taken, and the depth of the ditch below the grade pegs marked on the 'finders', the grading of the ditch is best accomplished by stretching a strong cord or wire, usually 5 ft. above the intended bottom of the ditch. This is most readily done with the aid of a rod divided into inches and fractions, and of the same length that the grade

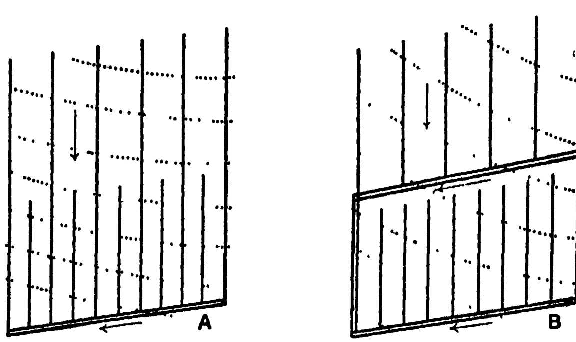


Fig. 38.—Grouping of laterals to permit them to be placed nearer together in one portion of the field.

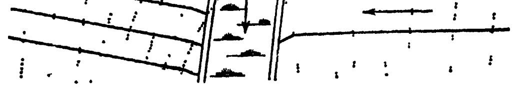


Fig 39.—Using double main to avoid change in grade of laterals.

line is to be set above the bottom of the ditch, 5 ft. in the case stated, numbering down, beginning at the top. To use this rod at any grade peg, note the depth desired for the ditch as marked on the 'finder'. Set the foot of the rod on the top of the grade peg, and bring the grade line to the same figure on the rod as that indicated on the 'finder'. The bottom of the ditch will then be 5 ft. below this line.

When it comes to digging the ditch, the work should begin at the outlet or at a junction with a main or sub-main, and proceed up the grade to the end. The tiles have already been distributed in the field along the lines of the proposed ditches. It requires not a little practice before a labourer becomes sufficiently skilled to dig rapidly and well a satisfactory ditch with sides straight, of proper depth, and without wasting time in removing more earth than is needful. A line should always be stretched along one edge of the proposed ditch, to which the labourer works; and the grade pegs should never be disturbed until the ditch is completed and the tiles partially covered. Ditching spades, with blades 18 or 20 in long, are most satisfactory for this work. In recent practice, however, blades with square rather than rounded corners are found to be more satisfactory than the types represented and longer in use. In doing the work the spade is thrust into the earth the full depth of the blade in good digging, a little quartering to the line, and the whole of the earth laid out in the manner represented in the Plate (upper

illustration), where a relay of four men are seen to follow, one after the other, completing the excavation as they go, with the exception of the final shaping of the bottom and bringing it to grade for the reception of the tiles. At this place four men are digging for an 8-in. main 5 ft. deep, the last bite of the spade being in a rather stiff clay, at the time lying about 1 ft. above the ground-water surface. In removing the last spading of earth great care should be exercised not to thrust the point of the spade nearer than within 2 in. of the intended bottom of the ditch, as it is very essential for good, permanent work that the tiles should rest firmly upon solid undisturbed earth. The last earth from the bottom of the ditch is removed with the tile hoe, seen lying at the right in the foreground in the illustration, which the operator takes up in steps after he has progressed about 4 ft., removing the loose earth and giving the preliminary rounded shape to the bottom of the ditch for receiving the tiles.

Where the work is carried forward methodically by a gang of men, another workman gives the final finishing to the bottom, bringing it accurately to grade by measurements from the grade line as already described. This work is done from the bank of the ditch with the aid of the tile hoe, guided by measurements made from the grade line, which is stretched along the margin of the ditch.

After the bottom of the ditch has been brought to grade and given the proper form to receive the tiles, these are best laid in place with the aid of the tile hook, seen in the hands of the workman in the Plate (lower illustration). In using the tile hook, a section of tile is raised from the ground and transferred to the bottom of the ditch, where the operator, standing on the bank, easily rolls and shifts the tile with the aid of the hook until a perfect joint is secured and the tile in proper place. The section of tile laid across the ditch in the engraving, to serve the purpose of a scale when the photograph was taken, shows the width to be about 16 in. when the depth was 4·5 ft. When the bottom of the ditch has been carefully shaped, the tiles lie securely in place, forming a true, even line, as seen in the illustration. Tiles larger than 8 in. must usually be laid by the workman from the bottom of the ditch, which must then be shaped with the shovel rather than with the tile hoe or scoop. In laying the tiles, as in digging, the work should begin at the outlet or at the junction with the main.

In filling the ditch, after the tiles are properly in place, it is first necessary to pack about the tiles sufficient clay to cover them 2 or 3 in. deep, much care being exercised to so place the earth as not to throw the tiles out of alignment. In case tiles larger than 6 in. are laid, some tamping of the returned soil will be necessary, to ensure against the danger of displacement by subsequent settling of the soil on account of the larger volume of the soil immediately against the tile.

Where the bottom of the ditch is firm, the tiles are always laid so as to make a close joint on top, the tiles being shifted and turned until this is secured. If, on the contrary, the bottom of the drain is quicksand, which is liable to flow into the tile, the closest joint should be secured at the bottom, and the top of the tile covered with clay. Tiles never should be covered directly with sand, as it is liable to work through into the drain; if necessary, suitable soil must be brought from a distance in sufficient quantity to cover the tiles.

After the tiles have been covered sufficiently deep with earth to be safe from displacement, the balance of the filling may be accomplished by any method most convenient and expeditious, *e.g.* by means of a plough drawn by a team, where the horses walk on opposite sides of the ditch, drawing the plough by means of an evener some 16 ft. long. To facilitate filling by this method, the earth may be thrown out alternately on the right and left banks of successive ditches.

It is important, usually, to get the ditches filled as quickly as possible after the tiles are in place and have been 'blinded', to avoid the danger of the drains becoming clogged as the result of heavy rains washing the loose earth into the tiles. The danger of clogging in this way is very great if any considerable volume of surface water is allowed to flow into the ditch before much filling has taken place.

Much effort, ingenuity, and capital have been expended in attempts to perfect ditching machines for tile drains. Of the many machines which have been placed upon the market, none has come into general use. One of the most successful ditching machines now in use, and which may be regarded as having passed the experimental stage, is represented in fig. 40. This machine consists of a strong, rigid frame and platform carrying the engine and boiler, and is so designed as to be self-propelling, the machine moving in front of its work, driving an excavating wheel some 9 ft. in diameter, the power being applied at the circumference of the wheel, directly above the work rather than at the axle. The excavating wheel is so mounted and hinged to the moving platform that it may be raised or lowered by the operator in securing the depth desired, and the speed at which the machine moves forward can be regulated by traction gears which may be changed at will. The excavation is accomplished by means of twelve or more buckets having semicircular cutting edges, and so inclined from the unexcavated earth as to reduce friction to the minimum. As the earth is shaved from the ditch by the buckets it is elevated to near the top of the wheel and deposited upon a carrier of 3-ply rubber belting which by its revolution deposits the soil at a safe distance from the margin of the ditch. With the aid of targets set ahead of the work, and the sight arm on the frame carrying the excavating wheel, a satisfactorily accurate grade may be established by the continuous advance of the machine once over the ground. Provision is made for the automatic cleaning of the buckets, which avoids interference from clogging where the soil is sticky. The very broad tires on the carriage wheels make it possible for the machine to be used wherever the ground is not very soft. The machine, of course, cannot be used among

PLACING TILE WITH TILE-HOOK

REMOVING THE LAST TWO SPADINGS FROM THE DITCH

tree stumps, nor where stones of any size are numerous in the ground. It may be managed by two men at a running cost of from £2 to £2, 10s. per day, and where the ditches are long, the ground fairly smooth and even, from 1100 to 1600 ft. of ditch from 2·5 to 3 ft. deep may be completed in a day of ten hours.

Selection of Tiles and Precautions against Clogging.—Tiles, to be durable, should be thoroughly and evenly burned, sufficiently hard to give a clear ring when struck. Many tiles left exposed in the field during the winter are liable to freeze, and crumble or 'slack' into fine chips, due to the expansive action of moisture freezing in them, although they may be durable when placed sound in the underdrain, below the action of frost. It should be kept in mind, however, that where shallow drainage is practised in cold climates there is considerable liability to failure, due to this crumbling of the tile. In our own experience we have known instances of crumbling in the case of an 8-inch main several rods back from the outlet, the fact being revealed in the spring when the frost went out, by the formation of a series of holes along the line of the main where the surface had caved in. This occurred during an exceptionally cold winter, and it is our opinion that it was facilitated by excessive ventilation. The drain opened toward the north-west, and this, with strong cold winds from that direction, would help to force cold air into the main and out through the pores in the soil. The more thoroughly the tiles are burned, the better the quality of the clay, the less is the tendency to injury by slacking, and the hard-burned, vitrified tiles, which are coming more and more on to the market, possessing more the quality of vitrified brick, are ideal in quality and possess all of the endurance of the best stone. Such tiles as these should be selected for extreme climates, especially where they must be laid shallow.

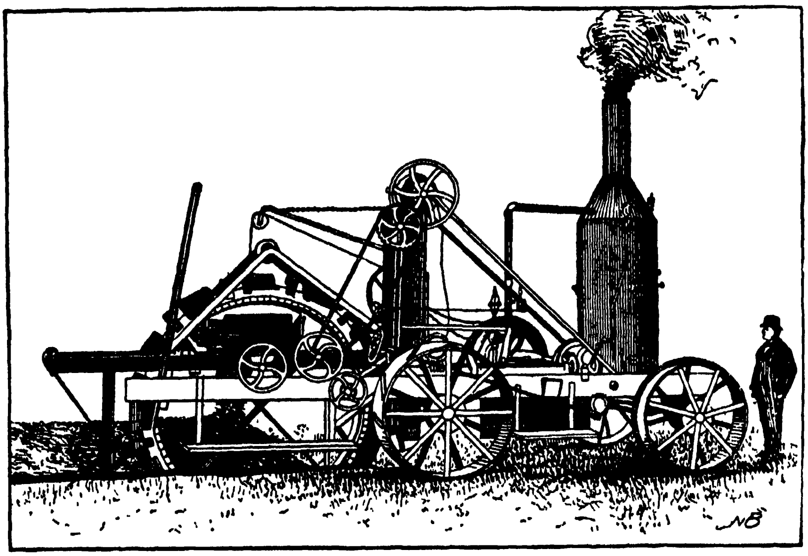


Fig. 40.—Traction ditcher excavating for tile drains.

Considerable work has been done in the direction of using cement in the construction of tiles, sometimes on the spot, but the results so far secured do not appear to warrant the expectation that such tiles are likely to have material advantage over those of well-burned clay, either in durability or in first cost.

There is no shape so satisfactory as the tile cylindrical inside and out. Those with one side flat, or which are made hexagonal or octagonal in outside cross section with the idea that they will lie more firmly on the bottom of the ditch, with less tendency to displacement, are not as desirable as would at first be thought. They are more expensive to make and heavier to transport, as well as being more liable to warp in drying and burning. The impracticability of the idea results from the fact that almost all tiles are more or less warped as the result of drying and burning, so that in order to make the joints fit closely together and at the same time fall into line they must be turned and shifted until the desired result is secured. This cannot be done so readily with any but cylindrical tiles.

Where tiles carry running water much of the time, the drains being only partly filled, there are many trees which, if growing near by, will send their roots, while yet thin and slender, into the drain between the joints of the tiles in quest of the perfectly aerated water; and after reaching the interior such roots grow and branch, until such a mass and network of fibres has resulted as will nearly or quite fill the tiles, in the manner represented in fig. 41. When such roots take possession of the tiles, through their excessive branching the silt carried by the water is arrested among the root fibres until the tiles may become completely closed. as had been the

case at several points in the main from which the illustration was taken. Willow and elm are other trees whose roots will travel long distances to seek running water in drains. A remarkable

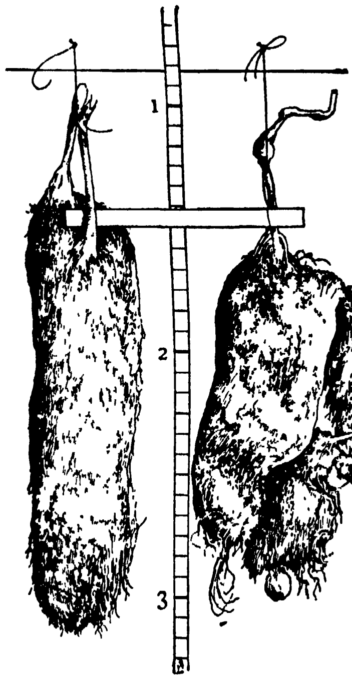


Fig 41 —Roots of European Larch which had effectually clogged a 6-in. main laid 5 ft. below the surface

instance is represented in fig. 42, where a root from an elm tree grew out into a dug and stone-curbed well 3 ft. in diameter until it reached the discharge pipe, in which there was a small drain vent through which water discharged whenever the pump was in use. Here, as shown in the illustration, the root subdivided into an immense bundle of fine fibres wrapped about the discharge pipe, where the water draining out could be utilized by them. It is important, therefore, in laying drains, especially in the case of mains and sub-mains, to remove all water-loving trees for a distance of at least 50 ft. In the case of mains passing near trees whose presence is desired, sewer tiles, laid with cemented joints, may be safely used.

Comparative Value of Lands Reclaimed by Drainage. — There remains for the future to develop into the full possibilities of fruitfulness immense areas of swamp lands, when measured in the aggregate, even in long-settled countries like Europe. In the United States east of the 100th meridian, recent estimates by the United States Department of Agriculture place the area of swamp lands at nearly 120,000 sq. miles. In Canada, in Europe, and in other parts of the world also, there are vast areas of land, when measured in the aggregate, which have yet to be drained, and much of which will ultimately become productive in varying degrees, some of it highly so.

In undertaking the reclamation of swamp lands there are certain general principles underlying their productive capacity which should be clearly understood and borne in mind: (1) All water-logged soils and subsoils are necessarily unproductive for most agricultural crops. (2) Complete, rapid, and deep underdrainage is one of the prime essentials to both the development and maintenance of the highest productive capacity in such, and indeed in all soils. (3) It is practically very difficult to secure, for lands requiring underdrainage, as deep and as thorough drainage as is provided by natural methods for most soils where standing water is usually continuously maintained at depths greater than 6 ft. below the surface. It cannot be expected, therefore, that soils requiring underdrainage can be made as productive as entirely similar soils which are naturally and deeply drained. (4) It is true, however, that such lands in most cases can have their productive capacities much improved, and often to a highly remunerative extent, by proper underdrainage. (5) There is an extremely wide diversity in the native quality of lands requiring underdrainage, in the possible degree of productiveness to which they may be raised, and in the amounts and frequency of fertilization which will be required for them.

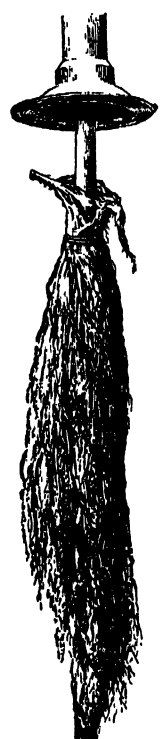


Fig 42.—Root of an Elm tree which entered a well, branching into a network of fibres around the discharge pipe to utilize the water escaping from the drain vent.

Such lands as have been built up by the overflow of great rivers, and have resulted from a deep and intimate commingling of organic materials with rich mineral soil ingredients, forming deep, broad, flat areas, are among the richest and most enduring soils in the world when they are drained to an ample depth. On the other hand, the peat swamps which have developed back from river courses, and especially over lake bottoms or over springy flats or slopes, where but little silt or other solid mineral ingredients containing essential plant food elements have become incorporated with the organic matter—so that beds 4 or more feet in thickness have resulted which still remain brown and fibrous in character—represent a type of one of the poorest of soils, if indeed the term of soil is at all applicable to them. Between these two widely separated extremes in the types of swamp land there are all gradations, and to classify such soils correctly, forecasting their relative agricultural values after being adequately underdrained, remains up to this writing an extremely difficult if not impossible task

The results of chemical analyses, showing merely the relative amounts of plant food elements and of available plant food present in them, may be very misleading unless the weight of dry soil per cubic foot or per acre foot is also taken into account. Thus, the coarsest and poorest siliceous sandy soils may carry a weight as high as 1950 short tons per acre foot; a fine loamy soil, one of 1400 tons; a black marsh or muck soil, one of 980 tons; while a heavy peat soil may carry as little as 500 tons, and a light peat soil as little as 300 tons per acre foot in dry weight. It is clear, therefore, that were the percentage composition of these different soils identical, the amounts of plant food elements and of plant food proper carried by them would be very different, and the same must be true so far as available soil moisture is concerned.

The chemical differences between fairly good and very poor naturally drained soils and others requiring drainage, in the United States, so far as absolute amounts of plant food elements are concerned, is shown in the next table.

Table showing the amounts of plant food elements in the surface foot of an acre of different soil types.

	Potassium (K).	Calcium (Ca)	Phosphorus (P)	Nitrogen (N)
	tons.	tons	tons	tons
Good average soils in United States	20·0	8·9	2·4	4·0
Black marsh soil, Wisconsin	11·5	12·6	·98	3·4
Poor sandy soil, Wisconsin	4·6	5·3	·79	·9
Peat soil, Wisconsin	1·5	6·3	·44	10·8
Michigan celery peat	1·9	25·5	2·1	9·6
Minnesota 'Muskeg' peat	·5	1·2	·38	11·6

Of 88 analyses of Austrian peats by Dr. Wilhelm Bersch, 1907, grouped in three classes, the analyses show the following amounts of plant food elements calculated to a depth of 1 foot.

Table showing the amounts of plant food elements in the surface foot of Austrian peats, expressed in tons per acre

	Dry weight of peat	Potassium (K)	Calcium (Ca)	Phosphorus (P)	Nitrogen (N).
	tons	tons.	tons	tons	tons
High moor	135	·09	·5	·06	1·7
Mixed moor	273	·23	2·7	·15	4·5
Low moor	408	·33	8·6	·29	9·5

So, too, in 143 Bavarian peats, analyses for the amounts of potassium found in the surface foot, classified in eight groups, showed averages ranging from only 104 lb. to 608 lb. in the surface foot of an acre, and the peats of the lightest group weighed but 150 tons, and those of the heaviest group 430 tons per acre for the surface foot. These analyses, from both Europe and the United States, show that peat soils proper, when compared with ordinary soils, are relatively very deficient in the essential plant food elements other than nitrogen. The black marsh or muck soils, although not always productive when reclaimed, and although often found deficient in available potash, phosphoric acid, and sometimes lime, are nevertheless usually very much more hopeful soils.

How little mineral matter the peat soils may contain, and how widely they differ from true soils can best be understood from the statement that 21 of the 88 Austrian peats cited above showed an average ash content of but 3·36 per cent, and 41 of them, almost half the whole number, but 5·77 per cent, while but 3 out of 88 showed an ash content above 50 per cent, the highest being 59·70. The contrast between these and true soils is made more striking when it is stated that the average ash content of the straw of maize, wheat, oats, barley, rye, and clover averages 4·75 per cent, and that of stable manure 5·52 per cent. These averages are of the same order of value as those shown by the 21 and 41 Austrian peats, and the comparison shows that the reclaiming of these types of land for agricultural purposes is not wholly unlike trying to cultivate fields deeply covered with decaying straw or average farmyard manure. They must be regarded as very special and peculiar soils, requiring special treatment, and well adapted only to special crops.

Where peaty soils have a depth of less than 3 ft. and are underlaid by a good subsoil, the prospect for their reclamation is fairly promising if there is present an ample content of lime. It must be remembered that the organic matter will shrink much when it comes to decay, and due allowance must be made for the fact in laying the drains. Where but a thin layer of peat, and this not well decomposed, is underlaid by a coarse siliceous sandy subsoil, there is but a poor surface soil and a poor subsoil, which ultimately must become the surface soil; they are, therefore, of little promise. [F. H. K.]

Drainage of Arable and Pasture Land in Britain.—Under the system of underdrainage the whole area of the field that is

to be drained is brought into uniform relationship with regard to the position of the water line in the subsoil. There is, of course, hardly any field to be met with the soil and subsoil of which are uniform throughout. But the skilled drainer takes note of the varying features of the various fields he is set to deal with. Accordingly he omits altogether the parts that are already dry enough for the purposes of the agriculturist, puts less work on those that are barely in that condition, while in those that are worse than the main part of the field he puts more, so that all may be in the desired condition by the time he has completed his work.

It is now generally allowed that from 2½ to 3½ ft. is a suitable depth for the parallel or smaller drains to be laid underground. Where free-working soils occur in districts not subject to drought this may be advantageously exceeded, but in the majority of cases it will be found to be deep enough to keep the water line from interfering with thorough tillage of the soil. The first of our drainers laid their drains deeper than we do. Four feet was a common depth. This is found to be too great in the heavy clay soils in Britain, in which the depth of the drains should not exceed 2½ ft. The idea was that by making the drains deep they might be placed correspondingly wider apart. This may answer in light land, but even soils of this class are apt to suffer from drought when the water line is at too great a depth. Thus the depth mentioned, while sufficient in heavy land to keep the water line from unduly affecting the surface, does not lower it too much in the case of light soils; and it similarly accommodates the various grades between these extremes. It is also deep enough to admit of very effective stirring of the soil. There is not much risk of any of our implements of tillage displacing the pipes of a drain 2½ ft. deep.

As regards the width between these drains, 15 ft. may be taken as the minimum, and that in the stiffest clays; and from 30 to 36 ft. in light soil. In many cases the customary width of the ridge governs the distance between the drains—the aim of the drainer being to have each drain in a furrow, or the hollow between ridges when the soil is under grass. There are many instances, of course, in which the land is not thrown up into perceptible ridges. In these the width at which the drains are ranged is ruled by the nature of the soil and other local circumstances.

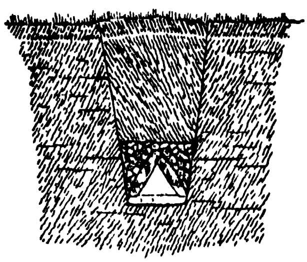


Fig 1

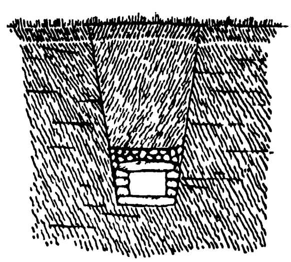


Fig 2

Pipes of a smaller bore than 2 in. are rarely used nowadays. Three-inch pipes are becoming the accepted standard. Two-inch pipes are occasionally used, but those 2½ in. in diameter are more frequently employed. As regards the pipes for the mains, they need be no larger than will allow them to deal effectually with the water which they receive. In the short lengths of subsidiary mains (where slight depressions occur in the course of a stretch of parallel drains) 3-in. pipes may be ample. Oftener, however, 4-in. pipes will be required. These will merge into fives, or directly into sixes it may be, for 5-in. pipes are not always available. Six-inch mains will be relieved by eights (if to be had), then by nines, and nines by 12-in. pipes failing tens. It will be a large field that will require a larger outlet main than a 12-in. one. And in addition to the field's share of water in the form of rain there may be springs tapped or intercepted in the course of operations, for which special allowance should be made in the laying of the mains.

The 6-in. pipe is more than double the area of the cross section of the 4-in. one. The square of the diameter of the tile multiplied by ·8 gives us approximately the area of the cross-section of the tile. According to this formula, the area of the opening of the 4-in. pipe—of its base, in short—is: 4 in. × 4 in. × ·8 = 12·8 sq. in.; while that of the 6-in. one is: 6 in. × 6 in. × ·8 = 28·8 sq. in. There is no apparent need for this sudden increase. At least the first half of the stretch of the 6-in. pipe might be served by a pipe of smaller calibre than is needed for the lower half. A 5-in. pipe gives us a drain with an opening of 5 in. × 5 in. × ·8 = 20 in., one just about halfway between the four and the 6-in. pipes.

The stone-laid drain is superior to all others in the matter of permeability. It is all joints and inlets together. Figs. 1 and 2 make this plain enough. Fig. 1 is the style of drain that prevails where flattish stones are the handiest. With these are formed the sides and base or sole of the triangular opening which the section shows. The other section represents the kind of drain made when rounder stones or small boulders are more convenient. In the latter case there is usually considerable difficulty in obtaining stones suitable for the sole of the drain, and if the sole be omitted, the bottom will be worn into irregularities, so that in time the drain will ultimately collapse in places.

The pipe drain comes far short of a stone one such as those referred to, in respect of permeability by water. No argument is needed, one would think, to support the statement that the more joints there are in the drain, the more effectively will the drain draw moisture from the soil. But there is a tendency at present to make the drain pipes (horseshoe tiles now being out of fashion) too long. Twelve inches used to be a common length. Now they commonly run from 14 to 15 in.

The horseshoe tile drain is practically a thing of the past. In some districts, however, there is still a considerable number in existence. But when these are renewed, the blanks are made good with pipes. Twelve inches being the standard length of the horseshoe tile, the sole was the same. These tiles had not reached the stage of being elongated (as the pipe has), by the time they were generally superseded. Fig. 3 gives a representation of such tiles and soles.

Cylindrical pipes are in vogue in England. Scottish makers appear to have most demand for a pipe such as fig. 4 represents. It is more or less similar internally—slightly oval usually—but is finished with a flat sole.

Leading drains should run with the slope. It is

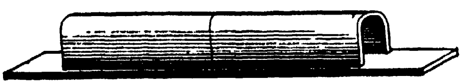


Fig. 3

not advisable to have them in too long stretches. Fourteen or fifteen chains may be taken as the maximum they should be allowed to run. If that does not bring them in touch with a main, then a sub-main should be introduced. The gradient should vary as little as possible. Whenever it decreases then the flow of water will slacken down. If the flow is quick at one place and slow at another, should there be more or less silt in the water, the silt will tend to deposit where the flow is least energetic, and by and by it will accumulate to the extent of forming an obstruction, thereby spoiling the part of the drain that lies at a higher level. All damage of this sort is prevented by keeping the respective drains as far as possible at one gradient. Matter in suspension will then be carried straight to the main, in which there is

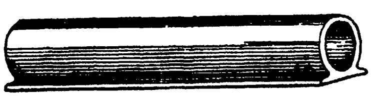


Fig 4

certain to be a stronger flow of water and less likelihood of silt being allowed to gather at different points. The more mains the more expense is incurred in draining, but there is no other course open than making plenty of them if a thorough and lasting job is desired.

Nothing dogmatic need be said with regard to the minimum gradient for drains. So long as they do not stretch too far, and have a clear drop into the main that serves them, it is surprising how small a gradient answers their purpose. But where flat-laid drains have a long run and a more or less obstructed point of delivery, they can never act properly. They will always be liable to suffer from the effects of backwater. But a drain with a short run and a free outlet will act even though it be but little removed from dead level.

There must be, therefore, no sparing of mains in ground that is irregular in outline, or in ground whose surface is smoothly undulating or altogether flat. The mains are intended to relieve the parallel drains, and if this is not done in the most effectual manner they are either injudiciously placed or they are too few in number. The main must be placed free from risk of obstruction. There must be no scrimping of gradient, even if this necessitates much extra excavation. In cases where the natural slope of the ground is too small for the gradient of a proposed main, then the necessary gradient must be given at the expense of further excavation. It may turn out that a main may be too deep to allow of direct communication between it and the smaller drains alongside, in which case a supplemental or intermediary main becomes necessary. Every main should be laid so much deeper than the smaller drains that these may be allowed a clear fall. When the small drains have a drop into the larger, it matters little at what angle the two are joined. When they join at pretty much the same level, however, the smaller must enter the larger at an acute angle.

Operations begin at one or other of the outlets of the scheme of drainage which it is proposed to take in hand, whether it be a detached plot or a complete field. There may only be one outlet, in which case this will form the starting-point. The scheme will previously have been planned out on the ground, the number of pipes and relative sizes taken into account, and levels worked out in those instances where there were flat places whose relative positions in this connection could not be estimated sufficiently close with the unaided eye alone. This would be done by the person entrusted with this department of estate work, in company with the foreman drainer. After these preliminaries had been arranged, with the work thus roughly planned out for him in the field, the latter official would be left in charge of the detail work of the job. Should he not have enough men on his regular staff he finds others, and putting all on piecework sets about the operation in a businesslike way. He usually lays off the line of the respective drains by means of a few pipes set up on end, and the work begins. Each man gets a drain at a time to himself, which he finishes, in readiness for the laying of the pipes therein, filling it up after these are in place. If the foreman has time he lays the pipes himself, otherwise he employs a trusty man on day's pay to do so.

The drainer commences by stretching out a stout string, say 2 chains long, in the same way as a gardener does his line, and with this as guide, with foot on delving spade (see Plate, fig. 1) strikes it deep through the turf, and thus notches off one side of the drain. The same is done with the other side, allowing a width at top of 18 in. in the case of the minor drains and a little more in the case of the mains.

Having cut through the turf at each side of the line of chain, the operator next removes the same in slices the full breadth of the cut and as thick as can conveniently be disposed of with his spade, laying them in order close alongside to be convenient for the tilelayer when he

starts operations. The turf thus disposed of, he may next be able to remove several inches of soil with the spade he started with. It is not long, however, after the sod has been lifted before he takes hold of the draining spade proper, such a one as is represented in Plate, fig. 2. It is longer in the blade than an ordinary spade, but narrower, and tapering towards the point. With this alone, should the ground be free of stones, he is able to do nearly all the required excavation. He may occasionally have recourse to his long-handled shovel with a blade after the type of fig. 3 (in Plate), and throw out the loose stuff that escapes the spade. As a rule, however, he does not require to do this until the last spit is at hand. Much depends, of course, on the nature of the subsoil which is being dug into If it be stiff clay, the drainer can raise the narrow spade with its full load, and throws the latter out whole almost unbroken. On the other hand, if the subsoil is inclined to be stony or friable the shovel has to be brought into use. If it be hard as well, the pick with head, as in Plate, fig. 4, must also be employed. When both pick and shovel are required, draining is tedious work compared with those instances where the draining spade is alone sufficient for the work of excavation. It requires vigorous effort to push the long narrow blade of the drain spade fully into the subsoil, and the drainer's right boot is armed with an iron shod or 'tramp' which enables him to shove the spade in with due effect.

With the draining spade he works to the bottom of the trench, gradually tapering it in on both sides with a view to having it no wider there than the pipes with which it is to be laid. He gives it the finishing touch with a tool such as is shown in Plate, figs 5 and 6, the head being either flat or rounded according as the bottom of the drain is to be finished.

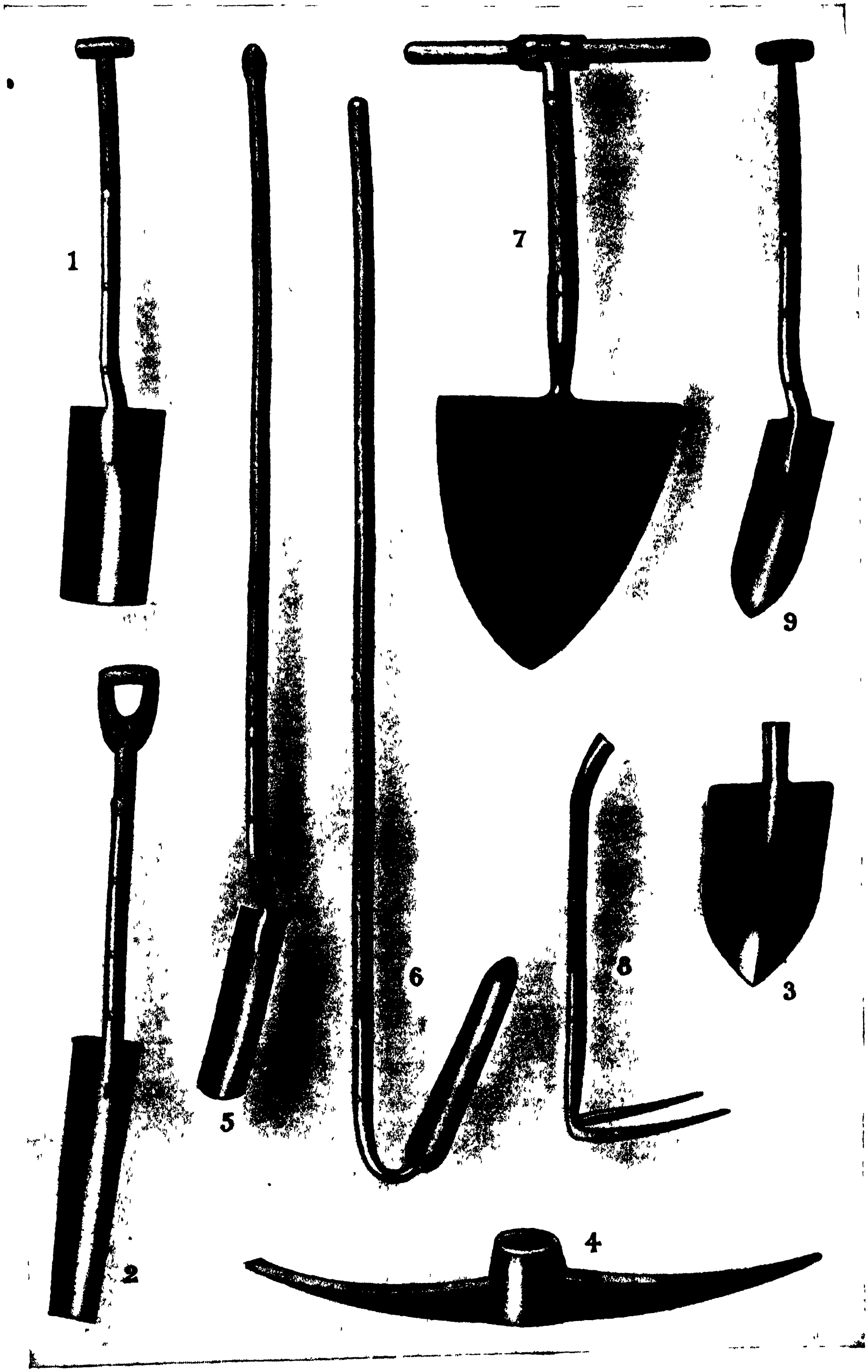
The trench is now ready for the pipelayer, the pipes having been stretched out alongside the drain. He takes his place in the trench and lays the pipes in position, walking backwards as the work proceeds. He protects them with the slices of turf first cut out After this the labourer who cut the trench is at liberty to fill it in. The pipelayer cannot move so well along the bottom of the trench that is finished off round as in the flat-bottomed one He lays them from the surface, therefore, with the aid of a drain-laying rod. With this he catches up a pipe, lowers it into position, and taps it home. This plan has the advantage of keeping the pipes better in line than the other, and one can finish the circular-bottomed drain to a more exact fit for the pipes.

Naturally the labourer seeks to excavate as little as he can from the trench which is the preliminary to the formation of the drain. He cuts it no wider than will give him room to work until the bottom is smoothed off. Draining on soil bearing grass admits of the neatest work being done. One can use the turf for laying next to the pipes, thus preventing the entry of loose soil into the pipes. Draining on stubble or on 'red land' has the advantage that the farmer, if so disposed, can give the trenches a start by turning a large furrow out of each to begin with, and when the drains are completed help materially to fill up the trenches by the same means.

The drainage of land, even on the simple lines suggested, is a sufficiently expensive business to make those who are to be interested therein sit down and carefully count the cost ere they begin. In some instances it may approach closely to half the capital value of the land itself. Taking the extreme instance of stiff clay land, that must be drained with parallels at a minimum distance of 15 ft. apart, this will necessitate about 44 chains of these being laid for each acre, thus: 4840 (the number of square yards in an acre) $\div$ 5 (the distance between drains) = 968 yards, which further divided by 22 (the number of yards in a chain) gives us 44 chains. Now half a crown a chain is not far from being a fair price for cutting and filling drains 30 in. in depth; nor is threepence a chain for laying the pipes in them far out. This gives us £6, 1*s.* an acre for labour alone. To reckon with the pipes next, we have 44 chains to base upon. This is equal to 968 yards, 2889 ft., or 34,668 in., which divided by 14 in , the probable length of the pipes available, gives us in round numbers 2500 pipes to provide per acre. Prices for these will be found to differ, of course, but taking them at 40*s.* a thousand, here is other £5 an acre to be faced. Draining such as we are supposing is not likely to be often done for less. It has every chance of amounting to more. Much depends on the nature and number of the mains that may be required, the cost of which falls to be apportioned over the full area of the ground before one can give the average cost per acre of the total work. Our calculation takes no note of this. On the other hand, we are liberal with the length of the parallel drains. We have deducted nothing for endings. Against this, however, there is the main running parallel with one ending or the other—there may be one at each ending should the field dip to both sides; and sometimes an ordinary drain is carried along the higher side of the field, hugging the boundary there more or less closely.

These figures afford a fair idea of how expensive land drainage is. At the other extreme of light land, with drains cut wide apart, the cost becomes proportionately less. But here, too, a great deal depends on what mains have to be provided. We have said nothing about the carting of the pipes to the ground to be drained, and their distribution along the sides of the drains within easy reach of the man whose duty it is to place them in position. The carting is often a considerable item, however; even when they are delivered at the nearest railway station.

After the completion of the drains, a plan of their position in the field should be made, and thereafter plotted out on the 25-in. Ordnance Survey sheet which includes the field. With this as guide, one is able at any time to point out where the outlets of the mains are, so that an occasional inspection of them may be made. It gives a plan generally of the system of the drainage of the field, and the jottings in con-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nection therewith afford an authentic record of how and when the work was carried out. An example of such a plan is shown in fig. 5. It is surprising how soon the details of a drainage job are forgotten after the land has been ploughed once or twice. But if the drains have been well laid, while they prove effective and do their part it may seem a matter of small moment whether or not one can point to their exact position underground.

One of the most frequent causes of stoppages in drains is the choking of the outlets. Usually a special finish is required at these outlets. Sometimes it is necessary to face them up with stone, and it is well in most cases to have a few lengths of fireclay pipes giving a finish to the end of the drain. Pipes of this class are in 3-ft. lengths, and stronger otherwise than those of drain-pipe clay. Where there is risk of slight submergence now and again (such as where the outlet is into a streamlet that is affected by floods), then pipes might with advantage be of the class with spigot and faucet joints. With them the main might, where practicable, be laid water-tight as far up as the flooding of the beck or burn would be likely to cause backwater in the drain. Gratings are in many cases necessary at the end of the main to prevent the entrance of rats, rabbits, &c. (see preceding article).

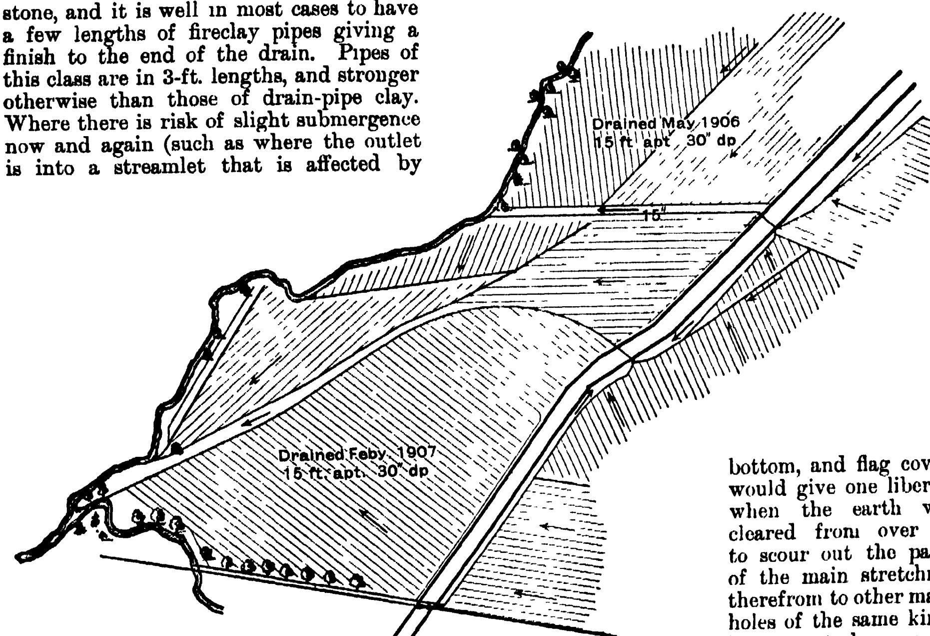

Fig. 5

Another frequent cause of stoppage in drains is due to the precipitation of iron oxide. This is almost peculiar to the poorer classes of soils, and is most marked in the first stages of their reclamation. It is caused by a superabundance of iron compounds in the soil, which the rainwater as it percolates takes up in solution and carries down to the subsoil. The iron in the soil exists mainly as the sub-oxide, which being soluble gets carried down by the drainage water to the drains. Here it becomes oxidized to one of the higher and insoluble oxides and becomes deposited in the drains wherever there is a slow current. Were it an ordinary powdery deposit it might not do much harm for a long time. But it issues forth as a fluffy, slimy, red-coloured stuff which very soon closes up the drains into which it finds its way. The only remedy in such a case is to open the drains and clean out the tiles. In the case of larger drains, it might be practicable to open the drains in places and scour sections with the drain-cleaning rod or by means of wires to which cleaners are attached. This can only be done when the drains run in straight lines, never in curves. At each angle of a main, however, there would require to be manholes of a kind such that each length could be dealt with separately. An 18-in. square place, say 1 ft. in height, with brick sides, concrete bottom, and flag cover, would give one liberty, when the earth was cleared from over it, to scour out the parts of the main stretching therefrom to other manholes of the same kind. Permanent bases such as these would be more satisfactory than merely excavating to the drain at the respective angles, and removing a pipe or two to gain room for insertion of the wire, and free play to make use of it with effect They need not cost much, and they would be out of the way of the implements of tillage. Drains are frequently choked by the roots of water-loving trees. To avoid such an occurrence, all mains and sub-mains should be kept at least 18 ft. clear of all hedges and fences

More or less temporary covered drains have been attempted. We have heard of enterprising crofters using a sort of rope of twisted heather instead of pipes or stones in drains. This laid in a peaty soil would certainly last a considerable time. The drains would have to be in short lengths, however, and with a quick gradient, to be of much effect. Their service in the matter of promoting the passage of air through the soil, however, would be slight. But better the rough-stemmed heather than straw in this respect. Branches have been used in much the same way.

In some districts a kind of covered drain, witl

out drain pipes or any such artificial aid by way of channel, is used with some effect. That termed the shoulder drain can be made to last for several years. Fig. 6 represents a drain of the kind we are referring to. It is cut more or less perpendicularly at both sides until a certain depth has been attained. In the centre of the sole thus formed a groove is made, leaving a shoulder or level break at either side. Over this is placed, face downwards and resting on each shoulder, the grass turf removed from the top of the trench. The trench is then filled, and the drain is complete. A drain of this description is merely an open channel left in the subsoil. The many chances there are of this opening becoming obstructed we need hardly do more than hint at; and once an obstruction is formed, the drain's usefulness is near an end. The wedge drain is much the same as the last. It is cut tapered, however, in the same form as the tile drain. Then lumps of clay shaped to fit tight to the sides of the drain, but too broad to allow

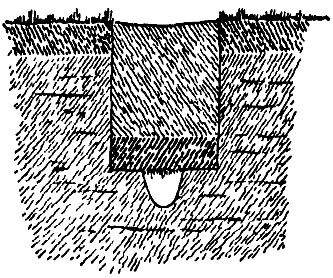

Fig 6

them to rest on the sole of the drain, are squeezed into place, and the trench filled as before. Here, again, we depend on a continuous open space along the bottom of the drain.

Another form of this class of drains is the plug drain. The trench is cut in the ordinary way, and a jointed rod or series of plugs of a section suitable for the open channel desired to be left is placed on the bottom and the excavated stuff returned, the first portion of which is tightly packed round the rod. When all the earth has been thrown back into the trench and the drain is thus completed, the sinuous or flexible rod is pulled forward till almost clear and another length is filled in. Considerable force is, of course, required to draw forward this core with such a depth of earth over it. It is not very long, however (5 or 6 ft. say), and by means of a chain attached to it in front, and a punch or lever stuck in the bottom of the trench, it can be dragged along without much difficulty.

Coming between the drains which are finished with pipes and those which are merely continuous and clean-cut holes underground are those spoken of as 'mole-drains'. A drain of this description is, however, little better than a deep scratch in the ground. It is executed with an implement like a subsoil plough, which has a sort of coulter and share with a torpedo head. As the implement is drawn ahead, it leaves behind it a slit with a wider conduit like a mole-run below. The slit will be almost closed from the beginning, but the wider channel below will keep more or less open (even though it may never claim to be a drain in the proper sense of the word) for some time after the operation. At best, however, this is a mere apology for draining. Drains of this kind are well named mole-drains, approaching so closely as they do to mole-runs in character. It has been claimed for this method of draining land that it is well adapted for strong clays under grass—it would be useless, of course, had ploughing to be done on the ground. The work can be done comparatively cheap, at a few shillings per acre it is said, but the plant is dear to begin with. The mole is dragged along by means of a capstan anchored some distance in front, set in motion by a horse. But mole-draining can be done in a more thorough manner if wished—that is, it can be done deeper. Traction engines and correspondingly improved 'moles' are available when one wants the business gone into a little more effectively. It would seem, however, that the cost involved would go far towards the more thorough system of pipe draining.

In the reclamation of lochs, bogs, and mosses, the initial step as regards the first is to bring up a cut that will effectually lead off the hemmed-in water, and be deep enough as well to afford an outfall for the thorough underground drainage of what was erstwhile the bed of the loch. It may be necessary at same time to lead catchwater ditches round the sides of the area in order to intercept the runs of water that have acted as contributaries to the loch. After this the bed of the loch, now free from water except what falls upon it from above, or perchance rises from beneath in the form of springs, can be dealt with on its own merits—if with sufficient promise of fertility, to be pipe drained; if badly situated and not otherwise inviting, to be surface drained with a view to serve as rough pasture ground.

The draining and reclaiming of bogs or mosses proceed much on the same lines as in the case of lochs. In the draining of peaty ground, one must make full allowance for the subsidence or contraction of the stratum to be affected by the drains. When these begin to act, the soil, which is always more or less of a spongy nature, contracts in bulk, and the surface subsides in accordance. The drains do away with its constant state of wetness, after which, on account of the open texture of the peaty stuff of which it almost wholly consists, the soil shrinks considerably. In cases where such a step is practicable, were one to cut down to the impervious rock or clay over which the bog has been formed, the large body of peaty matter, thus relieved of a great amount of the water characteristic of its constitution, would shrink so much as to become difficult to deal with. Not only would it subside more or less irregularly on the surface; it would also break up into wide and deep cracks or fissures, leaving one the onerous work of toning all down to a tolerably workable upper layer. But when not deprived of its large store of moisture in such a radical manner, the bog

can easily be turned to good account by going very little deeper under the surface than the ordinary drain level of arable land.

It is wise, however, when dealing with a virgin subject of this nature, to begin the work of drainage by means of open trenches. In fact, one can hardly do otherwise. It is only practicable to start in the comparatively easy way one takes with an ordinary field. A deep ditch or two serve, in the first place, to remove excess of water from the immediate surface. This gives one some freedom to move about on the ground. Cross ditches communicating with those first cut serve further to ameliorate the surface, and render it firmer. Leading from these there may now be run surface drains following the line of future parallel drains, after which cultivation of a kind becomes practicable on the surface. Left thus for a season or two, the groundwork gradually becomes fit for pipe draining. The ditches would be brought to a level sufficient to act as mains, the open drains leading into these would be deepened for the reception of pipes, while other drains alongside or between the original ones would be formed in accordance with the circumstances of the case. Instances of this sort afford one the chance of turning the shoulder drain to account. The dry turf which ground of this kind affords makes for the time being a capital cover for the underground opening. By the time these drains have run their course the ground would then be fit enough for the installation of the tile drain.

There are in many districts stretches of more or less boggy ground mixed up with the arable land of farms, necessitating its being underdrained. Subjects such as these, however, are usually in such a condition that the drainer can start upon them without more ado. Here, as before, though in smaller degree, allowance has to be made for shrinkage of the ground after underdrainage. The trenches must accordingly be cut to the increased depth that will counterbalance this shrinkage—how much beyond the accepted standard of the district for arable land must be decided by the special circumstances of the case. Ground of this description seems to contract very much under close tillage. We have seen, when redraining parts of it, the pipes of the original drains, which must have been at a fair depth to begin with, now only a foot or so under the surface. In this kind of ground the pipes require support underneath, else they will lose continuity of gradient. The mossy stuff is too soft to bear them up uniformly. To safeguard this, either pipes with collars in which the contiguous ends of pipes abut, or soles of wood like long thin bars of railing, are used. The former is only practicable in the case of circular pipes. Of course, no precaution of this sort is necessary when the bottom of the trench touches the hard subsoil in which the moss has been formed.

On the sheepwalk, draining is necessary as well as in the field. In this case, however, it is surface water only that is sought to be got rid of. On the rough ground it hampers the movements of the sheep, and prevents them being assured of a dry bed, while if suffered to encroach upon the grassy stretches alongside streams and burns, it favours the spread of liver fluke, which means serious loss to the flockmaster. Open or surface drains—'sheep drains' they are termed in some districts—serve the aim in view on these rough pastures. They are unimportant affairs compared with the tile drain. Little more than the turf is excavated in their case. But the turf of rough pasture is usually tough and wiry of root, and a strong effort is required to displace it. That is, away from the green spots. There the notching spade and shovel are good enough tools. But on the rough pasture a special spade, such as is shown in Plate, fig. 7, has to be used. It is more a knife than a spade, and a keen edge has to be maintained. As with the tile drain, the sides of the opening are lined off with a cord, along which with vigorous application to the two-handled head the operator drives the spade well home, slanting it to give the required 'batter' or slope to the sides of the drain. This done, he proceeds to slice off pieces

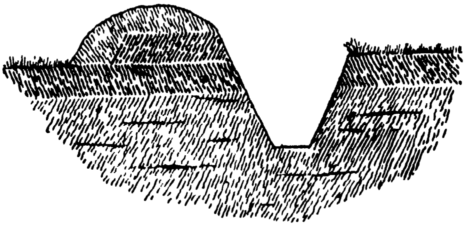

Fig. 7

at right angles to the drain. As he detaches a piece, an assistant or partner hooks it with the tool (see Plate, fig. 8), and lands it on the lower side of the drain face downwards, leaving the row almost in as close order as when the turf lay undisturbed over what is now the drain trench. A little smoothing off and general finish with spade or shovel are all that now remain to be done to the drain. The thicker the turf the less loose soil there will, of course, be to throw out.

These surface drains are led across the slope of the ground rather than with it. In this way they are quicker to intercept surface water as it comes trickling down the slope, little at first it may be, but assertive enough ere the flats are reached. But with drains not far apart stretched across its path, the descending water is led aside before it ever has chance to gather volume as well as speed. The width between the drains varies, of course, with the nature of the ground. Seldom, however, are they as close together as field drains. Fig. 7 will give an idea of the section of these open drains. It will be noticed that the excavated material is laid along the lower side of the drain, the turf (upside down) nearest to the drain, and the scoopings just behind this. The upper or higher side of the drain is thus left free to let the surface water trickle in. The cost of these surface drains runs somewhere about 90*s*. or 100*s*. a thousand poles, or between 4*d*. and 5*d*. a chain. What with the sheep breaking down the sides, and the encroachments of herbage, drains of this description call

for an overhaul comparatively often — say every six or seven years at the outside. Sometimes the tool in Plate, fig. 7, is again requisitioned for cleaning-out purposes; generally, however, the notching spade, and a scouring shovel, such as in Plate, fig. 9, suffice. The expense of scouring them afresh when pretty much out of order comes to about 80*s.* a thousand poles, or 3½*d.*, say, a chain. On some of the large sheep farms one or two persons are employed all the year round keeping the surface drains in order.

There are stretches of boggy ground on many sheepwalks that are better left without the benefit of drains. On these—the flow mosses as they are sometimes termed—in early spring, the sheep find plants with long succulent stems half in the ground and half out (like a leek, if the leaf bases can be called stems), which afford them a welcome bite when there is not much else of a juicy nature to be had. When these places are rendered dry beyond a certain stage, the 'draw mosses', as the shepherds call the plants referred to, cease to flourish, and the sheep are thereby deprived of a tempting addition to their otherwise somewhat uninviting bill of fare. The places in which grow the plants we speak of cannot very well be made fit to bear good grass—at any rate with surface draining only. Better, therefore, to leave them useful in their way, if only for a few weeks in spring, than interfere with them by introducing drains that render them of little or no value at any time. Such places are eyesores, no doubt, to many men concerned in pastoral affairs, but seeking to amend them too much is apparently not in the interests of the sheep

One point has to be guarded against with surface drains. Care must be taken that they are not given too quick a run. Scouring of the bed will follow whenever a drain of this sort has too high a gradient There is not so much fear of this in respect of the small drains Led at more or less of an angle across the hang of the ground, one can regulate the gradients of these. But with the mains this is not so easy, inclining as they are bound to do with the natural lie or slope of the ground. One can zigzag them to some extent, however. When an open drain has a long run and a quick descent as well, there will soon be a fan-shaped spread of boulders and gravel to mark the point where the rush of water loses its vehemence. After every downpour of rain there will be more deposit left to testify to the erosive effects of the fast-flowing main. The same applies to ditches of all kinds. Left to themselves, our burns and streams have worked out routes seawards that now cause the minimum of friction between forces, in accordance with the special physical conditions of each. This has been accomplished under conditions in accordance with which neither time nor the displacement of material was an object. We can help a little here and there by gently easing a corner or such like. When we seek to do more, however, we are sure to stir up opposition among the forces that in the course of long years have adjusted differences and gained a long step towards equilibrium. The tyro, apt to be oblivious of all this, not only cuts off corners in some comparatively sluggish watercourse without hesitation, but in places shortens its course as well. This looks neater and more businesslike; but next time the 'waters are out' there is almost sure to be a day of reckoning thereafter for interfering unduly with what nature has worked out in a spirit of compromise. See also ARTERIAL DRAINAGE, SOIL, and succeeding arts. [R. H.]

Drainage in Law.—The word 'drainage' may refer either to the withdrawal of waste liquids and sewage from houses, or to arterial drainage of land. It is in the latter sense only that it is treated in this article. At common law all the water which falls on the surface of the ground belongs to the owner of the land on which it falls, and he may deal with it and appropriate it as he pleases, provided he do so before the water has arrived at, and is flowing in, some natural channel already formed. He is also entitled to rid himself of it, if he wishes, in a natural manner. It therefore follows that the rights of coterminous proprietors are determined by the natural situations of their respective estates, or, in other words, that the inferior tenement is obliged to receive the water which would naturally fall from the superior. According to the law of Scotland, differing in this respect from English law, the owner of land has an undoubted right to drain it for agricultural purposes in order to rid himself of surface water, and neither is the lower proprietor entitled to complain that the consequence of the drainage will be to send down a greater quantity of water, nor will a neighbouring proprietor be entitled to complain that the operations have deprived him of water which would otherwise have flowed over his land. Further, the lower proprietor is not entitled to dam back the water so as to cause it to collect on the ground of the upper proprietor. 'But as this right'—of drainage—'may be overstretched in the use of it, without necessity, to the prejudice of the inferior grounds, the question how far it may be extended under particular circumstances must be arbitrary' (Erskine). On the other hand, the upper proprietor cannot by any operations on his ground increase the burden imposed by nature, and is not entitled to bring on to his ground, and thereafter pass on to the ground of his lower neighbour, water which would not otherwise have found its way naturally on to his estate. But a proprietor, though entitled to drain his land, is also entitled to appropriate or divert percolating water as he sees fit, and the proprietor of the lower ground acquires no right through the flow of water from a drain to demand a continuance of the supply, even though he might have put it to some useful purpose, such as turning a wheel, nor can the right be acquired through enjoyment of the use for the prescriptive period. Thus it has been held that the flow of water from a drain for the purpose of agricultural improvements, though for twenty years, could not give a right to the neighbour so as to preclude the proprietor from altering the levels of his drains for the greater improvement of his land.

STATUTORY LAW.—(1) *England.*—The legislature has always looked with peculiar favour

on schemes for the drainage of land, and as early as 1531 a statute known as the Bill of Sewers was passed to further this object. This Act has been amended by a large number of subsequent Acts, while different districts have by local Acts obtained special powers applicable within the limits of their control. The objects of the Acts are carried out by Commissioners of Sewers appointed by the Crown, who have wide powers enabling them to maintain or improve existing works, or to construct new works necessary for the drainage or irrigation of land; embanking of land from the sea, tidal waters, or streams; the making of canals, or the construction of water-wheels, reservoirs, watercourses, &c., which would increase the value of any land for agricultural purposes. Instead of these Commissioners the Board of Agriculture may form an elective drainage board if one-tenth in acreage of the proprietors interested in the scheme petition to that effect. The expenses of the works are to be levied by a rate imposed on the lands affected in proportion to the benefit received. If, however, new works costing more than £1000 are required, the expenses may be levied by a special owners' rate. Further, by the Public Money Drainage and Improvement of Land Acts, provision was made for advancing money to private landowners for the purpose of enabling them to carry out drainage operations; and in order to facilitate effective schemes the Land Drainage Act of 1861 enacts that if anyone interested in land and desirous of draining same make application to the adjoining owner for leave to make drains through his land and such application be refused, it shall be decided by two or more justices (1) whether the proposed drains or improvements will cause injury to the adjoining owner or occupier, and (2) whether the injury that may be caused is or is not of a nature to admit of a money compensation. Provided no injury be caused to the adjacent owner, or the injury can be compensated by money, the applicant is entitled to a warrant enabling him, on payment of the compensation assessed, if any, to proceed with the proposed alterations. If, however, the decision is that injury will be caused to his neighbour which cannot be fully compensated by money, the applicant shall not be entitled to undertake the proposed work. After such drains have been opened, power is given to the applicant to enter on the lands for the purpose of clearing and maintaining them, and failing his keeping them clear, the owner or occupier of the lands through which they are made is entitled to clear them and recover the expenses from the applicant. The owner of the land through which the drains run is entitled to divert the drains on substituting others as efficient. All costs reasonably incurred by the adjoining owner in respect of any such application shall be defrayed by the applicant. Questions of difficulty sometimes arise when damage has been sustained through the failure of an adjoining occupier to keep clean the channels of ditches, watercourses, or drains running through his lands. If by any work done by him the course of a stream is affected or its current altered, a proprietor would be liable to his neighbours should injury be thereby caused. Apparently, however, he is not at common law under any obligation to take steps to prevent the natural silting up of the channel by mud or by the growth of weeds, &c. The Drainage of Land Act, 1847, however, has made provision for the cleansing of watercourses, drains, &c. By section 14 of the Act it is provided that where by neglect of the occupier to maintain or join in maintaining the banks, or to cleanse and scour or join in cleansing and scouring the channels of existing drains, streams, or watercourses lying in or bounding the lands of such occupier, injury is caused to any other lands, it shall be lawful for the proprietor or occupier of such lands to call on the neglecting occupier to maintain the banks or cleanse or scour the channels or to join in so doing, and on default for one month after service of the notice, the occupier of the land injured may execute the necessary work and recover the expenses or a just proportion thereof from the neglecting occupier. It is, however, provided that unless the drain, stream, or watercourse to be cleansed shall be the boundary of or immediately adjoining to the land of the occupier injured, no entry shall be made on the lands of any other person without the warrant of two justices, which shall be granted if it shall appear to the justices that the neglect of the occupier of the land so to be entered upon has occasioned injury to the lands of the applicant.

(2) *Scotland.*—The powers of the Commissioners of Sewers do not extend to Scotland, but the Public Money Drainage Acts and the Improvement of Land Acts, 1864 and 1899, are applicable. The Drainage of Lands (Scotland) Act, 1847, confers powers on private owners similar to those conferred by the English Act of 1861. The main object of the Act is to entitle a proprietor who could not otherwise carry out a proper drainage scheme to encroach on his neighbour's land for that purpose, an invasion of property which at common law is clearly illegal. The leading section enacts that where lands are capable of being drained or improved by drainage by means of works to be executed on the same and other lands for obtaining or improving the outfall or otherwise, any persons interested in the lands so capable of being drained or improved, and desirous of executing the works, but who are unable to do so by reason of the objection, absence, or disability of any person whose lands would be entered upon or affected by such works, are empowered to make application to the sheriff of the county, showing the means by which such drainage or improvement may be effected, and praying for authority to effect the same under the provisions of the Act. The Lands Clauses Consolidation (Scotland) Act, 1845, so far as regards the services of notices on the occupiers of the lands, is declared to be incorporated with the Act. The sheriff may, before proceeding to the enquiry, require security, if he think fit, for expenses. After enquiry has been made, the sheriff, if he be of opinion that the benefit to be derived from such drainage or improvement outweighs the damage to be done thereby, and the pro-

posed method of drainage is in the whole circumstances the best, and that such drainage or improvement may be effected without material detriment to the lands proposed to be entered upon or affected, and that the damage may be adequately compensated under the provisions of the Act, may authorize the execution of the works within a time to be limited in the order. It is provided that no order shall be made for allowing any works to be executed in any park, policy, garden, pleasure ground, or planted walk, or the avenue to any mansionhouse, without the consent in writing of the proprietor and occupier thereof. Provision is also made for the removal of obstructions on rivers, &c., preventing drainage outfalls, provided the same can be done without diminishing the water power of any factory supplied from such stream, and without injury to any salmon fishery. No order shall authorize any work whereby any spring, brook, or stream supplying any mansionhouse or offices with water, or contributing to the amenity or ornament of the house, &c., shall be diverted or affected, without the consent in writing of the proprietor thereof. Compensation is to be made for any damage done to the lands entered upon, and until it is paid no entry shall be made on any lands except with the written consent of the proprietor thereof. The sheriff, on the application of any person interested, may authorize him to enter on the lands when the works have been executed for the purpose of maintaining them, and the sheriff is empowered to allocate the expense among the parties deriving benefit in such proportions as to him shall seem just. The common law as to the liability to join in the cleansing of watercourses, drains, &c., is the same in Scotland as in England, and as the provisions of the English Land Drainage Act, 1847, above recited do not apply to Scotland, there is apparently no means for compelling co-operation of a neighbour to keep the ditches and watercourses clean. As for compensation for drainage executed by agricultural tenants, see under AGRICULTURAL HOLDINGS ACT. See also ARTERIAL DRAINAGE. [D. B.]

Drainage of Woodland Soil should always, if possible, be carried out at least two or three years before land is to be planted; because when once the land is carrying a timber crop, no matter of what age, it is seldom possible to thus artificially reduce the water level without materially interfering with the growth of the crop, owing to the disturbance occasioned in the root system and the food supply. While field drains are comparatively shallow and are usually made with pipes sunk in the ground, woodland drains are wide and deep open ditches, which are cheaper and less likely to get choked by tree roots and rendered inoperative. But in making roads through woods the use of big drain pipes is much cheaper than masonry culverts. The main principle in any woodland drainage scheme is that only the injurious excess of soil moisture should be drawn off, and that the lowering of the water level should not extend so far as to lead to unforeseen effects, such as the drying up of springs, interference with the water supply necessary for sawmill work, &c., as sometimes results from deep railway cuttings. In any effective drainage system there must be a sufficient fall towards some neighbouring water channel, the normal water level of which is below that of the water in the area to be drained. For practical purposes a natural watercourse forms the best outspill channel. The drainage can be simply and easily carried out at any time, if the water level in the outspill channel is always below that in the water-logged area; but if it be occasionally higher (*e.g.* as in tidal areas), then sluices are needed at the mouth of the ditch to prevent any inflow of water to the area being drained. And under any circumstances the work is best begun in the driest time of the year (usually late summer or autumn) If the work is only of a simple nature, the run of the ditches can easily be fixed with the assistance of the Ordnance Survey map and of simple levelling instruments; but careful levelling is necessary wherever the drainage scheme is extensive or the difference in level is very slight. Each extensive drainage scheme or section of a drainage scheme consists in a system of small feeders, which slowly collect the water and lead it off into side drains, that carry it away into the main drain leading to the outspill channel. The digging of drainage ditches should begin at the lowest point of the main drain, and be gradually continued upwards, towards the side ditches and the feeders. The main drain usually follows the line of strongest gradient towards the outspill channel, unless this is so high as probably to lead to scouring of the ditch walls. The depth and width of the main drain depends in the first instance on the amount of water to be carried off, but also varies according to the nature of the soil, as on light soil the sides have to be more sloping and the top width greater than on stiff land. Where the soil is light sand or gravel, the fall should only be just sufficient to enable the water to be carried off, and even on stiff soil a gradient over 2 to 3 per cent is very likely to produce scouring after heavy rainfall. On the sandy moors of the North German Plain a fall of about 1 in 2000 is considered quite satisfactory. The angle at which the side drains debouch into the main drain depends on the gradient, and on the nature and wetness of the soil, a low gradient and a stiff soil permitting of a more acute angle than a steeper slope and a lighter soil; and of course they should so be made to debouch into the main drain that the onward flow of the water may neither be checked nor be apt to scour and injure the latter. And in like manner the width, depth, number, and angle of the feeders supplying the side drains depend on the gradient, the soil, and the amount of water to be carried off. In practice the distance between side drains varies from 10 or 12 yd. apart on stiff soil, to about 20 in sand or gravel; and they are generally, on a rough average, about 4 ft. deep, with a top width of about 3 ft., and a bottom width of 8 or 9 in., while the small feeders are cut with almost perpendicular walls on stiff land. The cost may of course vary greatly, but may fairly be taken as averaging about 2*d.* a yd. for ditches of 3 × 2½ × ¾ ft., and 1*d.* to 1½*d.* a yd. for side

drains according to soil. Open drains, of course, require frequent inspection, and prompt removal of rubbish tending to accumulate and choke them. [J. N.]

Drainage Water, Amount and Composition of.—When successive small quantities of water are added to a perfectly dry soil, three distinct stages may be observed. The first minute quantity does not moisten the soil, but chemically unites with some of its constituents; this is known as hygroscopic water, and is not available for plants, indeed an ordinary air-dried soil never loses its hygroscopic water. Further additions of water moisten the soil, but the added water is all held to the soil particles by surface attractions with so great a force that it cannot separate or drain away; this condition is seen in ordinary moist soil. Such water is absolutely essential to the plant. If, now, more water is added, the amount finally becomes so great that it can now no longer all be held by surface attractions; the excess, therefore, either separates from the particles and drains away, or remains to fill up the pore spaces and make the soil water-logged. This is the drainage water; it must be removed or the plant cannot grow. The distinction between these three stages is more fully developed in the art. SOIL, WATER RELATIONSHIPS OF; for the present it suffices for the reader to bear in mind that drainage water is the excess over and above that held by surface attractions to the soil particles.

The amount of drainage water is therefore regulated both by the rainfall and by the intensity of surface attractions. Where the latter is slight, as in coarse sandy soils, drainage is considerable; where it is greater, as in loams and clays, drainage is less. Similarly, if a change is induced in the surface attraction by tillage or manuring, the amount of drainage is altered. Thus the drains on the Rothamsted plots receiving only mineral manures run much more frequently than where dung is supplied; although the soil itself is the same in both cases, the added organic matter has increased the surface attractions and decreased the drainage.

The simple relationship between drainage and surface attraction becomes modified when the soil particles are so small that movement of water is impeded. In such cases, *e.g.* in clay soils, we may get zones saturated with water alternating with dryer zones, and if it were possible to get an accurate picture of the soil down to the water table we should probably often find wetter and drier zones. When a saturated zone comes over the drain pipes these begin to run; an unsaturated zone, on the other hand, does not cause them to run. An inch of rain falling in twenty-four hours is therefore much more likely to set the pipes running than the same quantity of rain spread over a week; in the latter case a saturated zone does not form, but the water is drawn into the soil by surface attraction. We can now see why the drains will run even though they are placed far above the level of the water table. Indeed the functioning of the drains has often nothing to do with the water table, but depends only on the presence of temporarily saturated zones in the soil. In some cases, however, the drainage water comes from below, and the position of the drains then marks the highest position permanently possible for the water table.

Besides true drainage, there is always a certain amount of surface water draining through adventitious cracks and channels made by earthworms, decaying roots, &c., particularly when the rain begins. After a time this becomes less (see below).

A third important factor in determining the amount of drainage is evaporation. If water is being volatilized from a soil or taken up by a crop it obviously cannot drain through. Drainage is therefore less on cropped land than on fallow, less in summer than in winter. So close is the relationship between drainage and evaporation that the amount of drainage from a particular field for a number of years may be regarded as that part of the water supply that has not evaporated.

MEASUREMENT OF THE AMOUNT OF DRAINAGE WATER.—In trying to get an idea of the amount of drainage we must distinguish the total amount of water draining through the soil from the quantity flowing through the drain pipes. We have already seen that the drains work only when the soil is so compact that movement of the water is impeded; saturated zones form, and water gets away more readily into the drain than into the subsoil. Except, perhaps, in the case of a very heavy clay soil, measurements of water passing through the drains would afford no guide to the total drainage; the lighter the soil the greater the difference would be. Instead, therefore, of attempting to estimate the discharge from the drains, investigators have measured the amount of water percolating through a block of soil of known dimensions. This is called a 'drain gauge'. It is essential that the soil should not be disturbed during construction, and the method adopted for making one at Rothamsted is thus described by Lawes, Gilbert, and Warington (Journ. Royal Agric Soc, 1881, vol. xvii, p. 269): 'A deep trench was dug along the front of each intended gauge; the mass of soil was then gradually undermined at the depth previously determined (20, 40, and 60 inches in the three gauges respectively) and plates of cast iron, 8 inches wide and perforated with holes, were introduced to support the soil as the work proceeded. This perforated iron bottom was finally strengthened by transverse iron girders, and the ends of the plates and girders supported by brickwork on three sides of the intended gauge. The soil being now supported from beneath, trenches were made one by one on the three remaining sides of the block of soil to be isolated; walls of brick, laid in cement, 4½ inches thick, were built against the soil, and the trenches were again filled in with earth. The mass of soil was in this manner built in on all sides with brick and cement. The surrounding walls were carried 3 inches above the level of the soil, the edges at the top being made to slope outwards. . . . At about 1 foot 6 inches below the perforated iron bottom is fixed a large zinc funnel, of the same area as the soil above it; the drainage water from the soil falls on to this

funnel, . . . and is collected in galvanized-iron cylinders, fitted with external gauge tubes.' The surface of the gauges is kept free from vegetation.

Other gauges, often called lysimeters, are made by filling large vessels with soil. It is supposed that the soil in course of time becomes compacted by rain to a natural condition, but the results are obviously less valuable than where the soil has been left undisturbed.

1. *Effect of Nature of the Soil.*—In order to determine precisely the amount of drainage through different soils, it would be necessary to make gauges of the soils in question so close together that temperature, wind, distribution of rainfall, and other circumstances influencing evaporation should be the same for all. Lysimeters might be so constructed, but not proper gauges. Mr. Baldwin Latham has constructed two gauges not far apart at Croyden; one is a section of gravel in the valley, the other a section of chalk on the down at Ribblesdown. Both are 36 in. deep and covered with their natural turf. The results are published each year in British Rainfall. The averages for 1902 to 1906 are given at top of next column.

More grass grows on the gravel gauge than on the chalk, and consequently more water is

Average Rainfall 1902–06.	Drainage through Gravel.	Drainage through Chalk
26·39	11·70	13·16

evaporated; the observed difference in drainage is not entirely due to the physical properties of the soils.

Little is known about the behaviour of different soils beyond the general fact that the amount of drainage increases as the soil becomes coarser. Laboratory experiments on the rate of percolation through soils saturated with water do not quite furnish the necessary data, because a saturated condition rarely occurs in nature.

2. *Effect of Weather and Crop Conditions.*—Here the effect of soil texture is eliminated, since one and the same gauge is used for all the observations.

(*a*) *Temperature.*—In warm months drainage is less, both as a whole and as a percentage of the rainfall, than in cold months.

The average drainage through the Rothamsted gauge, 60 in. deep, for the different months of the years 1870 to 1905 is as follows[1]:—

	Jan.	Feb.	March	April	May	June	July.	Aug.	Sept.	Oct	Nov.	Dec.	Total.
Drainage in inches	1·92	1·44	1·00	·53	·49	·64	·65	·58	·74	1 64	2·01	2·01	13·65
Rainfall in inches	2·29	1·94	1·88	1·90	2·08	2·41	2 70	2·69	2·51	3·23	2·83	2·52	28·97
Drainage per cent of rain	83·8	74·2	53·2	27·9	23·6	26·6	24·1	21·6	29·5	50·8	71 3	79·8	47·1
Mean temperature[2] degrees F.	36·6	38·2	40·9	45·5	51·2	57·5	60·7	59·9	55·9	48·8	42·6	37·7	47·9

(*b*) *Rainfall.*—On an average about half of the rain drains through the soil of the Rothamsted gauges, but in wet years the drainage increases by an amount practically equal to the extra rainfall.

	Average Rainfall.	Drainage	
	inches.	inches.	Per cent of rain
Dry years; rainfall below 26 in.	23·45	9·69	41·3
Medium years; rainfall 26 to 30 in.	28·42	12·52	44·1
Wet years; rainfall above 30 in.	33·35	17·11	51·3

(*c*) *Wind.*—It is not possible to give precise data, but in general wind increases evaporation and decreases drainage.

(*d*) *Effect of Cultivation.*—Déhérain,[3] Wollny,[4] and others have shown that the effect of cultivation is to decrease evaporation and therefore increase drainage.

(*e*) *Effect of Crop.*—Crops decrease the amount of drainage, and the larger the crop the greater the effect. On many cropped soils there is practically no drainage in summer. The average annual amount of drainage through two gauges constructed by Mr. Mawley at Berkhamstead, one kept bare and the other covered with well-mown turf, was for the years 1900 to 1907[5]:—

	Rainfall.	Drainage through	
		Bare Soil.	Turfed Soil
	inches.	inches.	inches.
Winter months, October to March ..	14·14	12·30	9·07
Summer months, April to September . ..	11·95	4·74	1·94

The difference between the gauges is a minimum during the months January to May.

The Composition of Drainage Water.—Drainage water contains in solution greater or lesser quantities of all the soluble constituents of soil, and of all the soluble substances added to the soil unless they have been taken up by plants or organisms, or have reacted with some soil substance to form insoluble bodies. It therefore nearly always contains organic matter, lime, soda, magnesia, nitrates, sulphates, chlo-

1 Data taken from a paper by Dr. Miller, Journal of Agric. Science, 1906, vol. i. p. 377.

2 Twenty-six years, 1878 to 1903, mean of mean maxima and minima.

3 Annales agronomiques, 1898, vol. xxiv, p. 449.

4 Forsch. d. Agrik.-Phys., vol. x, p. 1.

5 Some older data are given in Warington, Physical Properties of Soil, p. 123; and in Wollny, Die Zersetzung der organischen Stoffe, pp. 330 et seq., and 369, 370.

rides, and carbonates; but, on the other hand, only small amounts of potash, ammonia, and phosphates are present, since these react with soil constituents and become insoluble. The actual amounts of all these substances present is very variable, and statements of average composition cannot be given. Voelcker's analyses, and those of von Seelhorst, given below, afford a good general idea of the magnitude of the quantities involved.

A large number of analyses have been made of water from drain gauges, lysimeters, and field drains; at Rothamsted special arrangements are made for collecting the drain water from the variously manured plots of the Broadbalk wheat-field. Usually nitrates and chlorides only have been determined, but in some cases complete analyses have been made; the data thus accumulated enable one to get a good idea of the various factors involved. Speaking generally, the principal materials lost are calcium bicarbonate and nitrates, the latter especially during autumn and winter.

Influence of Type of Drainage.—It has been pointed out in the preceding section that when rain first starts much of it finds its way through cracks and channels in the soil; the drainage water is therefore at first partly surface water, and is more dilute than the true drainage following later on.

PLOT 9

	September 10, 1896			September 11	
Date and hour of collection	12 noon	3 p.m.	6 p.m.	6 a.m.	9 a.m.
Nitrogen as nitrates, parts per million	4·8	9·2	11·5	10·9	11·0
Chlorine, parts per million	3·5	7·7	9·6	9·7	9·7

The composition of the true drainage remains constant for a number of hours.

One exception to the general rule has been found. On the rare occasions when the Rothamsted drains run soon after the application of ammonium salts or nitrate of soda, the first runnings are more concentrated than the later ones. Thus in the disastrously wet summer of 1879 ammonium salts were applied to Plot 12 on March 12, and heavy rains came on before the nitrate formed had time to get distributed through the soil. The surface water was therefore richer than the true drainage, and the water collected on April 7 when the drains began to run contained:—

	7 a.m.	9 a.m.	11 a.m.	1 p.m.	3 p.m.
Nitrogen as nitrate, parts per million	25·4	18·2	14·6	12·6	11·2
Chlorine, parts per million	83·4	58·8	50·2	43·4	37·6

Influence of the Amount of Rainfall.—During a wet season the drainage water steadily becomes weaker because the soluble material gets more and more completely washed out of the soil. Very heavy rainfall has a marked effect; the true drainage of constant composition collected during the very wet September of 1896 contained:—

PLOT 9.	On Sept. 10 and 11.	On Sept 13 and 14.	On Sept. 23.	On Sept. 26.
Nitrogen as nitrate, parts per million	11·0	9·9	8·7	7·5
Chlorine, parts per million	9·7	8·6	7·7	6·6

4·11 in. of rain had fallen during these fifteen days. For the same reason the drainage usually becomes weaker as the winter progresses.

By February the amount of nitrate was reduced to 4 and of chlorine to 3·6. The following year, 1897, was dry, and the drainage was therefore more concentrated; the difference in composition is very striking.

	Nitrogen as nitrate, parts per million.		Chlorine, parts per million.	
	Wet year, 1896.	Dry year, 1897.	Wet year, 1896	Dry year, 1897.
Dec.	8·3	16·8	6·6	11·3
Jan.	5·9	17·7	4·1	11·3

The effect of rainfall is seen most clearly on the drain gauges, where there is no crop to take up the nitrate. The nitrates reach a maximum in September and fall off steadily till February, when they begin to slowly rise again. For the 60-in. gauge the average amounts of nitrogen as nitrate in parts per million are:—[1]

Sept	Oct.	Nov.	Dec.	Jan	Feb.	March.	April.	May.	June.	July.	August.
12·23	11·42	11·05	9·90	8·45	7·89	8·17	9·27	8·84	8·36	10·34	11·72

The quantities of drainage and of rainfall have already been given.

Besides the general falling off in the amount of substances present, there is also a change in their nature as winter progresses; the acid radicles, nitrates, chloride, and sulphate are washed out more rapidly than the bases, so that

[1] Miller, Journ Agric. Science, 1906, vol. 1, p. 382. Dr. Miller has also kindly furnished the writer with many of the other data quoted.

there is a steady increase in the amount of bicarbonate. The complete analyses made by the late Dr. Voelcker bring out this point very clearly.[1]

Unmanured plot drainage.		Bases.				Acids.		
	Total solid matter.	Lime.	Magnesia.	Potash.	Soda.	N as nitrate.	Chlorine.	Sulphuric acid.
Jan. 13, 1868 ...	258·7	102·0	4·6	2·4	5·9	6·7	14·6	25·0
April 21, 1868	202·1	85·1	6·7	1·0	9·6	·9	8·3	11·0

The quantities are stated in parts per million.

The decrease in acid radicles is equivalent to 26·8 of lime, while the fall in the bases is equivalent only to 10·3 of lime; the difference indicates an increase in bicarbonates equivalent to 16·5 of lime.

Influence of the Crop. — Constituents taken up by the crop obviously cannot appear in the drainage water; the summer drainage from cropped land, even when it occurs, contains very little nitrate, and the safest way of preserving the nitrates in the soil is to have a crop growing during the late autumn and winter months. Drainage from ground which has recently carried a crop is also weaker in nitrates than drainage from fallow land. These points are well illustrated by comparing the drainage from the gauge, which is kept fallow, with that from the Broadbalk unmanured plot; the amounts of nitrogen as nitrate, in parts per million, were in 1898 and 1899:—

	Nov.	Dec	Jan	Feb	March	April.	May.
Unmanured plot ..	11·6	5·9	3·4	1·7	No drainage.	No drainage.	
40-in. drain gauge	14·0	11·1	10·1	7·1	7·0	7·1	6·07

The November drainage from the plot is slightly lower in nitrate because much has been removed by the previous crop; in January and later months the plot drainage is much poorer because the crop on the ground is taking up the nitrate.

On the other hand, if a substance is not taken up by the plant the difference between the gauge and the plot drainage is only small. The values for chlorine during the same period were:—

	Nov.	Dec	Jan	Feb.	March.	April.	May.
Unmanured plot .	14·4	7·7	6·7	6·0			5·0
40-in. drain gauge	7·6	6·8	6·5	6·2	5·6	6·0	6·8

Complete analyses of drainage water from cropped and uncropped lysimeters were made by Hanamann in 1896, and are reported in the Jahresbericht über Agrikulturchemie ii, 1899, p. 30; and iii, 1900, 31.

Lysimeter experiments are made at Ploty (Podolie, Russia) by Welbel, whose reports are abstracted in the Experiment Station Record, and at Göttingen by von Seelhorst. These will in course of time give very useful results. Von Seelhorst[2] has also made complete analyses, at first each week and afterwards each fortnight, of drainage water running from a field during the year Aug. 1899 to Aug. 1900. The results in parts per million are given in the following table:—

	Lime.	Magnesia.	Sulphuric acid.	Potash.	Nitric acid (N_2O_5)
Highest figures	184	46·4	59·2	3·7	8·2
Lowest figures	157	31·3	43·5	1·7	1·0

Influence of Manuring.—There are three ways in which manuring may affect the composition of drainage water.

(1) It may cause greater development of crop, and so reduce the amount of plant food getting into the drainage; this effect is naturally only seen in summer and in autumn before crops are removed.

Nitrogen as nitrate, in parts per million.[3]

	March to May.	June to Sept.	Aug. to Oct.	Oct. to March.
Plot 10—Nitrogen only	28·7	11·4	17·8	9·5
Plot 13—Nitrogen + phosphates and potash	27·8	1·9	8·5	10·3

[1] Journ. Roy. Agric Soc., 1874, p. 132. These analyses are dealt with more fully in the art. MANURES, EFFECT OF ON SOIL.
[2] Journal für Landwirtschaft, 1901, xlix, 251. For the lysimeter experiments see vol. liv, 1906, p. 313.
[3] Means for 1878 to 1881, Lawes, Gilbert, and Warington, *op. cit.*, p. 110.

(2) It may itself get into the drainage water; thus nitrates will get in, and ammonium salts will change to nitrates, which will then get in.

Plot 9 (Nitrate of Soda)		Plot 2 (Unmanured)[1]	
Feb., before applying nitrate.	April, after applying nitrate.	February.	April.
19·1	66·7	13·5	4·6 parts of nitrogen as nitrate, per million of drainage water.

[1] 1880 results, *ibid*, p. 110.

(3) It may act on the soil and make some constituent soluble, which then gets into the drainage water. Thus dressings of ammonium sulphate increase the amounts of nitrate, sulphates, and lime in the drainage water. Addition of chloride or sulphate of potash increases the chlorides or sulphates, the lime, and the magnesia. This part of the subject is dealt with in the art. Manures, Effect of on Soil.

Effect of Depth of Soil.—In soaking through the soil to any considerable depth, drainage water undergoes various slow changes, so that spring water may differ considerably from drainage water. See Soil, Absorption of Substances by.

Attempts to estimate Loss of Fertilizing Material by Drainage. From the foregoing account it is clear that drainage is influenced by too many factors to enable one to say precisely what amount of fertilizing material is lost each year. It is estimated at Rothamsted that 800 to 1000 lb. of calcium carbonate are washed out of the top 9 in. of every acre of soil each year, but no estimate can be given for the loss of nitrogen. See Calcium Compounds in Soil; Nitrogen, Losses of from Soil; and Soil, Changes taking Place in.

The Leaching Action of Drainage and Productiveness.—Unless a certain amount of soluble material is washed away, the conditions described under Alkali Soils set in. The leaching effect is therefore not entirely harmful to fertility.

For further information see Lawes, Gilbert, and Warington, Journ. Roy. Agric. Soc., 1881, 241, 311, and 1882, 1; Miller, Journal of Agric. Science, 1906, vol. i, p. 377; King, Physics of Agriculture.

Summary.—The amount of drainage depends on (1) the rainfall; (2) the intensity of surface attraction of soil particles for water; (3) the amount of evaporation and transpiration. Any condition affecting these will influence the amount of drainage. The composition of drainage water depends on (1) the stage at which the sample is taken, the earlier runnings being partly surface water; (2) the amount of rainfall; (3) the crop; (4) the nature and amount of manure supplied to the soil. [E. J. R.]

Draught, Principles of.—The progress of a country may be largely estimated by the quality of its roads, for roads afford the means of intercommunication and development. The perfecting of roads and rail tracks is meant to lighten the draught of loads, and therefore to decrease the cost of freight. The first aim is to secure a level track with as slight grades as possible, especially where mechanical tractors are used. Theoretically it is so where horses are used; but when horses are confined to roadwork entirely, it has been found that those working on perfectly flat roads break down sooner than those which work on moderate gradients. This is caused by constant strain being thrown on one set of muscles in one case; while in the other, additional muscles are brought into work, thus giving occasional relief; it has analogy to the case of a man who becomes more tired by standing in one position for a lengthened period than he would if he took gentle exercise. This indicates that when considering the question of draught, the difference between a mechanical motor and an animal should be regarded; a machine may be strengthened to effect work wherever the stress comes, but an animal's strength is where it is found, and cannot be augmented. It is for this reason that certain points in a horse are held in high esteem for one class of work, and are less so for others. Apart from this exemplification, there is no doubt that a level track is most favourable; whenever a gradient has to be climbed, a certain amount of lifting has to be accomplished, and it is found on a hard smooth track that the draught increases in the ratio of 1 per cent to each 1 per cent rise—that is, for each 1 ft. rise in 100 ft. It is an accepted principle that in overcoming any resistance or doing any work, the force or power doing the work, when multiplied by the distance through which it moves, is always equal to the resistance or work multiplied by the distance through which it is moved. Thus—

$$\text{Power (P)} \times \text{Power Distance (PD)} = \text{Weight (W)} \times \text{Weight Distance (WD)}.$$

There are, however, several other features to be considered, such as the smoothness of the road bed, rigidity of the road bed, width of tire, diameter of the wheel, distribution of the load on the carriage, direction of the line of draught, rigidity of the carriage. The rigidity of the road bed is of first importance, for when a wheel sinks in as it proceeds, it is constantly undergoing a process of climbing, moreover there is a tendency for the wheel to skid with the yielding ground. The increase in draught is greater with a small wheel than with a larger one, as the arc of the circle is proportionately less. Many experiments have been made to demonstrate the measure of draught on roads of varying firmness, all of which confirm ordinary experience. The width of the tire has been shown in series of trials to confirm practice, that a wide tire, 6 in., is easier of draught than a very narrow, 1·5 in., where there is yielding, but with a perfectly hard bottom the narrower had the advantage. In farm practice from 3½ to 4 in. is best for general work, though on soft

clay soils a wider wheel is occasionally preferable; and small wheels are not so easy of draught as are larger. It is very commonly held in loading wagons and lorries that it is a mistake to place the greater weight over the hind wheels, on the ground that being farther from the horse the draught will be heavier. The load should, however, be in proportion to the surface the wheels presented to the ground, thus on ordinary wagons most should be placed behind. On soft ground it is still more important, as the front wheels provide a compressed track for the hind ones. The direction of the line of draught is one which may vary considerably with the type of motor. In the case of mechanical motors, as in a railway train, the locomotive running on a smooth unyielding steel rail, the line of draught is most efficient when it is parallel with the rail; but the same effectiveness is not so secured by animals, which are not able to apply their force to the greatest effect horizontally. Man, for instance, ordinarily assumes an upright position, and is better adapted to lift than to pull, for taking his feet as the fulcrum, and though he will incline his body forward, the centre of gravity when pulling is but little in front of his feet. In the case of the horse, however, where the body is horizontal, but the fulcrum also the hind feet, there is a very considerable weight in front of them; and as in moving, the horse can extend its legs behind the body, the centre of gravity is considerably in front of the hind legs when the horse is standing naturally, the line of draught is therefore much more oblique than in the case of man; and it is found that a horse travelling at walking pace pulls most effectively when the traces are at an angle of 18° to 20° below the horizontal, though the length of the horse and its height, as well as the relative weight of the fore quarters, prevent a definite angle being fixed upon as applicable equally in all cases. When a horse is traced above the horizontal line, there is a great tendency to lift it off its fore feet, and all this tends to reduce the weight it can put into the collar. When pulling a four-wheeled carriage, in which the front wheels are smaller than the hind, the inclination of the traces should be lower than when attached to a two-wheel vehicle, as there must be more power to lift to overcome special obstacles which have to be lifted or climbed over. In trace work the line of the four horses should be in a continuous line; for if the four horses are pulling upwards they tend to lift the phill horse, and if downwards they put stress on its fore legs. [W. J. M.]

Draught Ox. See ANIMAL LABOUR.

Drench. See MEDICINES.

Drew, Lawrence (1826–84), son of Mr. Lawrence Drew, farmer, Carmyle, Lanarkshire. Born there, and educated at the old Glasgow High School. Entered the service of the Duke of Hamilton at Merryton in 1845, and gradually rose in office until he became factor on the Hamilton estates in Lanarkshire. An enthusiastic lover of the Clydesdale horse, he built up for the Duke a splendid stud of these horses at Merryton home farm. Many of the best mares of the breed were found in this stud while it lasted, and at the first International show held at Battersea, London, in 1862, its representatives under Mr. Drew's management won high honours. When the ducal stud was given up, Mr. Drew took it over, and became tenant of the farm of Merryton, which he occupied for a period of about twenty years. He continued to breed and exhibit Clydesdale horses until his death, but during the later years of his life he imported many mares from England, which he mated most successfully with the Clydesdale stallion Prince of Wales (673). Some of these mares were got by the Clydesdale stallion Young Lofty (987), which travelled for several years in Derbyshire, while others, and perhaps a majority of them, were Shire mares. He won the highest honours at the shows of the Highland and Agricultural Society, and other shows in Scotland and in England, with these south-country mares and their produce (see under CLYDESDALES). Mr. Drew was also an enthusiastic breeder of Ayrshire cattle. He kept a herd, in some respects unrivalled, and has by some been blamed for fostering the craze for 'small-teated' Ayrshire cows (see under AYRSHIRES). Many of the best showyard Ayrshires passed through his hands. Mr. Drew took an active interest in public affairs. When the Board of the Highland and Agricultural Society was remodelled, and nomination was placed on a popular basis, Mr. Drew was the first popularly nominated representative for the Glasgow show district. He held this office until his death, which took place very unexpectedly in March, 1884, just on the back of a signal triumph for his principles of breeding at the Glasgow Spring Stallion show. Mr. Drew was a consistent opponent of the principle on which the Clydesdale Horse Society was founded, and in 1883 led a movement to form a Stud Book or Register to which the name The 'Select' Clydesdale Horse Society was given. This movement did not long survive the untimely death of its leading patron. As an agriculturist, Mr. Drew occupied the foremost rank. His success attracted visitors from all lands to Merryton, and early in 1879 His Majesty King Edward VII (then Prince of Wales) visited the farm and stud, accompanied by His Grace the Duke of Hamilton and Prince Louis Napoleon, the son of the dethroned Emperor Napoleon III and the Empress Eugénie. [A. M'N.]

Drift. — When it became recognized that widely spread superficial deposits, resting on the solid rocks, had sometimes been derived from distant sources, it was suggested that vast floods had transported the material, and the deposits were said to be 'diluvial' (see art. DILUVIUM). Lyell, however, proposed the name 'drift' for all such accumulations, since the mode of origin was thus left unspecified. So large a proportion of the 'drifted' materials were proved to have been connected with the movements of ice that the name drift is now practically synonymous with what is strictly styled *glacial drift*. The 'drift editions' of maps published by the Geological Survey represent all manner of superficial deposits, such as the 'clay with flints' on the surface of the English Chalk; but in the present article it will only

be necessary to deal with the ice-borne material.

Glaciers carry forward any rocks that fall upon their surfaces, and many of these rocks descend through the cracks in the ice, and are used as tools to score the valley-floor down which the glacier moves. Fine dust and sand are blown or washed on to the ice, and similarly become embedded in it, often being covered by successive snowfalls. The glacier, when the joints in the rocks over which it moves are suitably arranged, exercises also a considerable 'plucking' action, and the blocks thus removed are associated with smaller material worn also from the floor or carried to its bed by streams. The great glaciers known as ice sheets, now well studied in Greenland, are seen to carry in their lower portions enormous quantities of mixed stones and sand and clay. The stones become scratched by rubbing against one another and by the sand grains

Separate Boulder (taken out of boulder clay), showing smoothed and striated surface

dragged against them. When the glacier shrinks away under climatic changes, the material left as it melts constitutes glacial drift, resting on a floor of striated rock.

The drift in the British Isles is now recognized as being almost entirely the product of land ice, or of ice that moved in places over the floor of shallow seas, thus banking out the water. *Boulder Clay* or *Till* is a loam or clay formed of finely disintegrated rock, with striated stones embedded in it. Its constitution, and even its colour, have some connection with the solid rock on which it rests, or with such rock a short distance away. Though it may contain some stones brought from very distant sources, yet it represents for the most part the old local soils and broken rock over which an ice sheet rode (see A. Geikie, Textbook of Geology, 4th ed., 1903, p. 1309). Here and there boulder clay shows bands of gravel in it; but the main mass is unstratified. Moved forward in the ice, and irregularly heaped up in it, boulder clay ultimately becomes left as a layer concealing and protecting the underlying rocks, entirely altering the conditions of drainage, and usually forming a stiff soil. Where floods from the melting ice streamed over it, the fine mud was washed away, and *Glacial Sands and Gravels* were deposited, with irregular stratification and very variable texture in their successive layers. The waters from the melting front of an ice sheet similarly spread out gravel deposits over wide areas, as may be well studied in Alaska. Such glacial gravels usually have good drainage, and may form great terraces on valley sides, from the base of which springs emerge. In regions from which the ice has passed away, the drift left in the valleys may form the only lands available for tillage; and glacial drift in general has profoundly modified the agricultural conditions of our own islands.

The 'chalky boulder clay' of eastern England, for example, provides fertile tracts in a region that would otherwise present to the farmer a surface of dry chalk downs or of stiff unmanageable Eocene clays. It stretches from the Yorkshire Chalk as far west as Coventry and as far south as London, and is rich in lumps of hard northern chalk, which often show glacial striæ. Similarly, throughout northern England, the only maps of the Geological Survey that give a clue to the variety and nature of the soils are the 'drift' series, the underlying 'solid' rocks being effectually concealed over hundreds of square miles. In Northumberland, to take one example, glacial sands and gravels frequently overlie the unpropitious Coal-measure series, boulder clay, on the other hand, may hide the calcareous sandstones of the Lower Carboniferous series. The till of southern Scotland, though its fine matter may be derived from local Coal-measures, contains fragments of metamorphic rocks from the highlands to the north; and Old Red Sandstone has given abundant material to the till in the basin of the Forth. The Carboniferous Limestone of Ireland has furnished a limestone boulder clay that spreads far beyond the limits of the central limestone plain. Gravels rich in limestone pebbles occur 1200 ft. up on the granite of the Dublin hills, and ameliorate the slopes and valleys of the Cambrian country of County Wicklow. The map published in Mr. Kilroe's Soil Geology of Ireland (1907) shows the vast area over which the farmer in Ireland depends on soils derived from glacial drift rather than from the 'solid' rocks below. See also arts. DRUMLIN, ERRATICS, ESKER, MORAINE. [G. A. J. C.]

DRIFT SOILS.—If all soils had been formed *in situ*, a knowledge of the underlying rocks, which could be obtained from the study of a geological map, would enable an agriculturist to infer, with a tolerable degree of accuracy, their nature and their crop-producing capabilities, even if he had never seen the actual ground. But comparatively few of them have been formed in place, and most of the solid rocks shown on the map are covered with a more or less thick mantle of drift. This covering of drift is often beneficial, as it represents a certain amount of mingling of detrital materials from different sources. Such a condition occurs in the extremely fertile lands of the Golden Vale of Limerick and Tipperary, the soils of which are limestone boulder clays enriched by much detrital material brought by the ice flow from the Old Red Sandstone country which lies away at some distance to the north-east. On the other hand,

instances occur where the drift, instead of improving a district, impoverishes the areas over which it is deposited. Such a case may be seen near Westport, where a sandy drift overlies the Carboniferous Limestone strata (Kilroe, Soil Geology of Ireland, p. 143).

Boulder-clay soils naturally owe their mineral composition, and to a certain extent their texture, to their parent rocks, while their colour, too, is largely determined by that of the predominant rock. Thus the boulder-clay soils derived from basalt are brown, those from limestone dark-grey, while those from the Old and New Red Sandstones are dark-red. Most boulder clays are really not clays at all, but rather strong loams with a variable percentage of boulders. The drift soils from the newer formations, containing clays, marls, and shales, are stronger and more clayey, but less stony than the typical boulder clays.

Drift soils may present a far greater variety of texture than those from a similar source that are directly derived. A gravel mound and a boulder-clay drumlin, for example, with totally different soil characters, may occur in juxtaposition; even a single knoll of drift may be seen to consist of boulder clay and sands and gravels interbedded, giving, within a very limited area, different soils at their outcrops. On the other hand, it often happens that soil samples from the drift taken over very extensive areas may show similar mechanical and chemical analyses, and represent, in fact, soils of similar crop-producing value.

Drift soils formed from the rock fragments belonging to the formation on which they rest are chemically and mineralogically not very different from the soils directly derived from the local rocks; but in the process of transport they have been subjected to various movements and assortments, which have completely changed the physical properties of the original rock debris. Such a rearrangement is apparent in the Sands and Gravels, and in the Upper Boulder Clay, where a certain amount of stratification has taken place.

Since the drifts have been deposited, their soils have undergone considerable modification from the washing action of rains and floods. The higher-level soils may have much of their finer material removed by the former agency, leaving a relatively large proportion of stones and of the coarser-grained soil particles behind, while the lower-level soils may be enriched by this accession of downwash from the hills. In consequence of the reassortment of soil particles just described, different types of soil may be derived from the originally more or less uniform drift, the soils on the higher grounds being more open in texture, freer to work, and with better drainage than those lower down. This is beautifully illustrated on the drumlins of Co. Cavan, where a change of slope and a change in vegetation mark the boundaries of the types. A further modification of drift soils may be seen in the delta fans appearing at the mouths of old river valleys, formed by streams that have long since disappeared, or that have shrunk considerably from their former proportions; these fans are really alluvial, and their soils do not differ materially from ordinary alluvial soils. The soils formed through the agency of glacial floods are characterized by the very high proportion of stones that they contain; they are usually much poorer than the soils from the adjoining boulder clay.

Frequently boulders of great size occur in the boulder-clay soils and subsoils, and are very often a source of much annoyance to the farmer when they come within reach of the plough. They have to be lifted and carried at considerable expense, or in the case of the larger and more refractory ones, shattered by explosives, or buried deep in the subsoil. [T. H.]

Drift Sands. See DUNES.

Drill Husbandry.—Drills may refer to the ridges on which plants are grown, or to machines for sowing seed in drill-husbandry. Drill-husbandry has been applied to the cultivation of corn and root crops, but more universally to the latter than to the former. The essentials of drill husbandry consist in the use of coulters, by which the seed is deposited in straight lines, or grooves, at fixed but easily regulated distances apart. The drilling of corn is general, especially in the case of barley. It ensures uniformity of distance between the rows, equal exposure to the sun during the early stages of growth, and equality of depth, and consequently of germination, all of which conditions are favourable to uniformity of sample. In the case of wheat and oats, broadcasting finds favour, and may be preferred in certain circumstances. In the south of England, where wheel landpressers are used to follow each plough, broadcasting does equally well as drilling, and the corn appears in rows of rather wider or less cramped character. In the case of root cultivation, drilling is universal for obvious reasons. It would be impossible to horse-hoe and difficult to hand-hoe root crops under any other system, although in old works we read of such hoeing, or 'houghing' as it was termed.

The advantages of drilling, as usually set forth, are not always applicable, and may be rebutted by corresponding advantages in broadcasting, dibbling, or ploughing-in; all of which are feasible in certain cases. It is claimed for drilling that it saves seed, allows of horse-hoeing, secures equal depth and a perfect cover, and that it is more uniform and exact than broadcasting. On the other hand, the saving of seed is somewhat doubtful, or at least is seldom thought of, while in the case of corn crops, drilling in most cases is not followed by horse-hoeing. As already explained, broadcasting on a pressed furrow ensures a good cover by harrowing; and in times before drilling became general, the perfect ploughing so constantly seen in anticipation of oats after ley, left little to be desired in the way of a seedbed. So far as corn cultivation is concerned, drilling and broadcasting still divide the field, and it is argued that the freer and less cramped distribution of broadcasted corn is actually preferable. This view is, however, scarcely realized in practice, as perfect uniformity of distribution by broadcasting is unattainable. As to cost and rapidity, there is no

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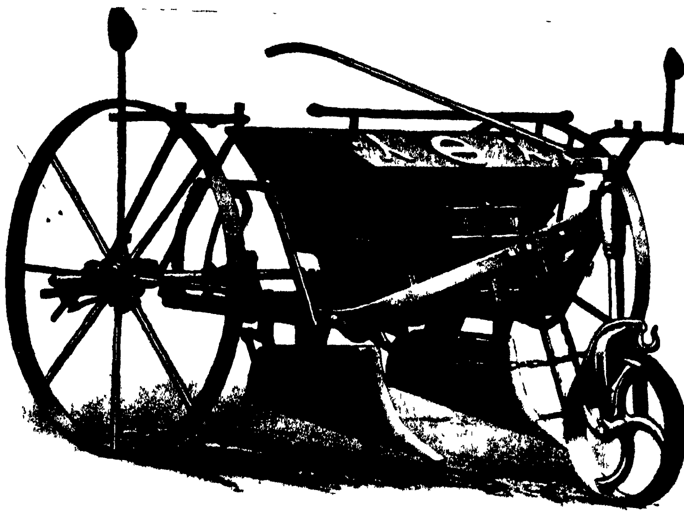

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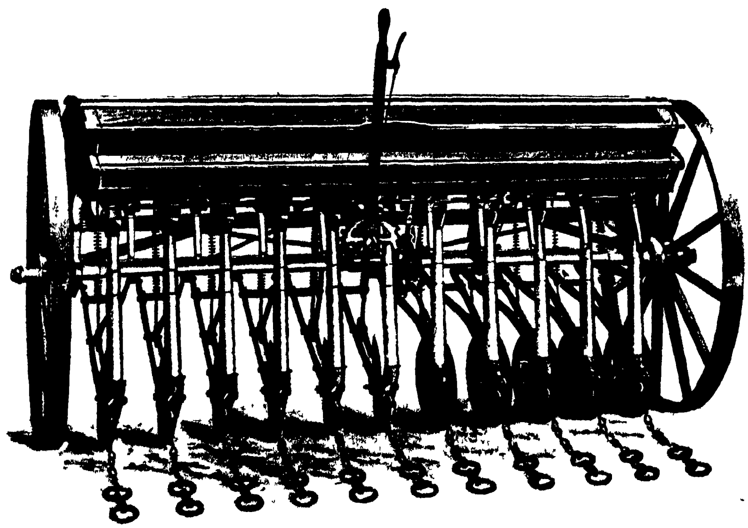

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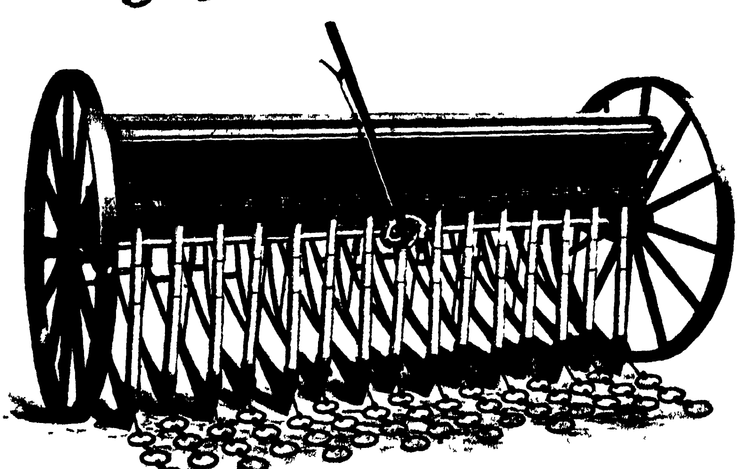
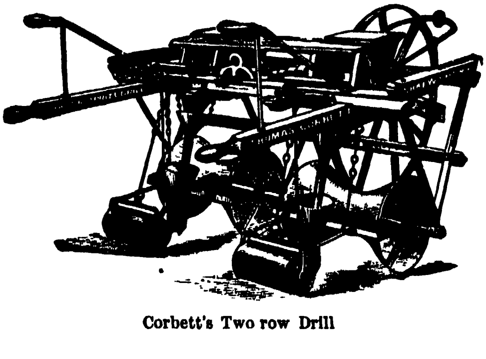


1, Wallace's Combined Double Drill Plough and Manure

doubt that in both these important points the advantage lies on the side of the older or ancient and classical system. In these respects it would be difficult for any drill to rival 12 ac. of corn broadcasted by a man in one ordinary day, at a cost of 3*d.* to 4*d.* per acre. It is, however, to be feared that the art of broadcasting by hand is in a measure lost. [J. WR.]

Drills.—Drills are distributors of seeds and manures which deposit these substances in the soil at a required depth in parallel rows or drills, whereas broadcast distributors scatter them on the surface only. Many of the principles employed in distributors are used in drills, additional parts being provided to effect the depositing (see also BROADCAST SOWERS). The corn or seed is conducted from the seedbox to the soil through funnels connecting with telescoping tubes of various types, the telescoping being necessary to meet inequalities of the surface of the land; the tubes generally end near the heel of the coulter, which makes the seed track, so that the seed necessarily falls into the coulter track. The coulters are attached at the rear end of long coulter arms hinged to a mortise bar at the front of the machine, all these parts being below the seedbox. The depth of the track made by the coulters is regulated by pressure from springs or weights applied to them in various ways, and the width of the rows is regulated by the distance apart of the coulters. Where it is intended that the crop shall be hoed, the drill should be provided with means to secure accurate steering, as otherwise it is impossible to hoe the rows where the several draughts of the drill join. Broadly speaking, the steerage provided is not so easy as it might be, though in the hands of skilled men excellent work is done. The most accurate steering is done on the Bedfordshire drill, which has a back steerage attached to the axle, freedom being obtained by reason of the main parts being pivoted on to the axle bar; the steerer gets an excellent 'middle mark' over the narrow rim of the wheel; the draught of these drills is somewhat heavy, as the weight of the box is largely carried on the coulters, but they make firm seed tracks for wheat. The more ordinary type is the Suffolk, with a fore steerage, the shorter leverage of which, and the absence of a 'middle mark', making it more difficult to steer accurately. The travelling wheels carry the main weight, and pressure is applied by weights attached to the coulter lever arms; an adjustable pulley prevents the coulters sinking lower than is desired where the seedbed is loose, while a presser bar prevents the coulters from rising beyond a certain height where the seedbed is rough and tough. A combined double drill and manure distributor is a type now frequently employed in the preparation of the land for the green crop. This machine opens two drills at a time and deposits the artificial manure in the bottom of the drills so made. The manure is fed from a hopper which has a revolving bottom, and through the agency of two star wheels is delivered into two spouts by means of which it reaches the ground. The width of the drills can be regulated from 24 to 29 in., and the amount of manure sown from 1 cwt. to 1 ton per acre. A water or liquid manure drill is used where it is desired to sow liquid manures with the seed of root crops. In the place of a hopper and feedbox there is a large tank, into which superphosphate and other manures are placed, water being added until the manures are brought into suspension. By means of dredgers and suitable contrivances this mixture is fed out into the spouts connected with the coulters; other spouts convey the seed to the same spout, and the two are deposited in the rows together. There are conditions under which this association of the seed with moisture acts beneficially in assisting the seed to germinate and the young plant to establish itself. Some care is, however, required on an ill-prepared seedbed in dry periods to prevent germination and malting. Drills of a lighter type than those mentioned are now frequently used, the Massey-Harris shoe drill representing such a drill in a very simple form,



Corbett's Two row Drill

suitable for colonial work or where hoeing is not likely to be required, but it has no steerage beyond ordinary driving. The principles of lightness have been adapted by many English makers to suit the drills to British needs. Massey-Harris's disk drill has revolving disk coulters in the place of the ordinary coulter; these are useful on newly broken-up pasture land, or where there is manure or other loose material which is likely to be driven by ordinary coulters. Drills to deposit seeds of turnips and other root crops in ridged land require special construction, and are usually made to drill one or two rows. Corbett's two-row root drill is a good example, with the several parts readily adjustable to varying conditions. Each row is provided with a concave roller for tightening the soil in the ridge, a seed coulter, and a light rear roller for covering the seed; the seed is fed by a cup feed in a separate box for each row. This drill can be used for drilling 'on the flat' by substituting plain rollers for the concave. Drills generally are made in sizes suitable to the requirements of holdings of any size, even down to a single row hand drill for garden purposes. Some makers specialize in drills for small holdings and market gardens. [W. J. M.]

Drills in parallel rows are usually formed in gardens with a hoe or pointed stick. The soil being prepared by digging and raking

the surface fine and even, the drills in which the seeds are sown are then drawn at the required distance apart with the assistance of a line, and the surface raked over. In the case of some seeds a roller may be passed over them. This is a quick and economical method for the raising of most kinds of kitchen-garden produce, as not only are the seeds more evenly distributed, but the working of the ground afterwards is so much easier than when the seeds are sown broadcast. The operation of thinning is also greatly simplified when the seeds are sown in drills. [W. W.]

Driving.—Easy matter though it be to describe on paper the correct way of holding the reins when an attempt is being made to instruct the uninitiated in the art of driving, it becomes a very different matter when the theories are being put to practice. In short, there is no difficulty in placing the reins in the correct position; the trouble is to keep the horses under control and to guide them subsequently.

The possession of a delicate touch, technically known as 'good hands', is essential to the success of any ambitious coachman whether amateur or professional, as he who bears heavily on his horse's mouth cannot by any possibility achieve greatness as a 'whip'.

In explaining the correct methods of holding the reins, it may in the first instance be observed that the backs of the hands should be carried downwards, and not upwards as in riding. In the case of single horses and pairs, the near or left-hand rein should be placed between the first and second fingers of the left hand, and the off rein between the third and fourth. When driving tandem place the second finger between the leader's reins, and the near rein of the wheeler between the finger and the thumb, and the off rein between the third and fourth fingers. When driving a four-horse team the second finger should divide the wheelers' reins, and the first finger the leaders' reins, by which arrangement the reins of the near wheeler and off leader are held between the first and second fingers. The reins should always be in the hands of the driver before he mounts the box, whether there are men at the heads of the horses or not, and before taking his seat he should satisfy himself that the harness is properly adjusted and the horses bitted as they should be. In order to prevent his reins catching on some obstruction whilst he mounts, the loop at the end may be temporarily hitched over the fourth finger of his left hand.

Finally, it may be suggested that there is a far too common disposition on the part of most people who drive to make too much use of the whip. Not one horse in a hundred is benefited by flogging for such offences as shying at an unfamiliar object or for stumbling. In the former case the fault is often excusable, and can usually be cured by firmness and common sense, whilst in the latter the mistake is as often as not due to carelessness or bad driving. In short, the whip is as a rule a good deal overdone, and many an owner of horses would like to see it dispensed with altogether. [V. S.]

Driving Horse.—The superiority of the British driving horse is conceded by the breeders of all nations, who testify to the conscientiousness of their opinions on the subject by visiting this country year after year with the object of recruiting their studs by the purchase of English stock. As a matter of course, the number of such sales as have taken place have enabled foreign horse-breeders to produce first-rate harness horses of their own, but still the demand for British blood continues, as it has done for a century past and longer.

Nearly a hundred years ago the Norfolk-bred Hackney known as Jary's Bellfounder was exported to America, and there achieved wonders in the way of improving the horses of that country, and laying the foundation of many a valuable strain of trotters, whilst the highest honours of the New York prize ring are even in the present day bestowed upon imported English and Scottish Hackneys. In view of such similar successes both at home and abroad, it is not surprising that the Hackney has earned for himself the title of the emperor of harness horses, and he is undoubtedly entitled to the distinction of being regarded as the premier driving horse.

The Cleveland Bay, another well-known breed, is best adapted to work in the state coaches of the nobility, and the heavy landaus which form such imposing features of the parades in Hyde Park during the season. This horse, however, is inclined to be somewhat plain about the head, and generally speaking deficient in quality; hence the greater amount of favour which is bestowed upon the closely allied variety known as the Yorkshire Coach Horse. The latter variety sprang into existence towards the commencement of the 19th century as a cross between the thoroughbred and Cleveland Bay, the object of his breeders being to produce an animal possessing much of the harness character of the Cleveland, but with more elegance about him.

The above are the three great harness-horse breeds of Britain, with the exception of the pony, which exists in so many distinct and interesting varieties, such as the Dartmoor, the Exmoor, the Welsh, the New Forest, the Fell, the Rum, the Connemara, and others. On the Continent there are such fine breeds as the Oldenburgh, the Holstein, the East Friesland and the lighter of the Percherons, the Orloffs and one or two other fine families of driving horse, whilst in the United States the trotting-bred roadster is the animal preferred.

Of course there are harness horses to be found in all countries, and in most of these there is a Hackney basis, for the presence of this blood ensures action, good looks, good temper, and an aptitude for work in leather amongst its stock. The great point, after action, to be secured in a harness horse is sufficient substance and weight to do the work required of it, but this must not be secured at the cost of quality. Coarseness is a serious defect, but so too is lightness of bone and a bad set of feet. Nor is the value of a horse's action solely dependent upon his ability to bend his knees, for he must use his shoulders and pasterns in front and flex his hocks. A

good head, neither too small nor too heavy, a powerful neck, shoulders not necessarily very sloping but still well enough laid back to ensure plenty of liberty, stout flat legs, big front feet of equal size, a body well let down, fairly well rounded ribs, a short level back, and long level quarters, a tail set on high and carried gaily, and good hocks are all features to be sought for in a driving horse; and if even a considerable majority of them are obtained, an owner can congratulate himself upon the possession of a good animal. [V. S.]

Dropsy.—Dropsy is a term of rather wide application, and usually implying an accumulation of watery fluid or of the serous portion of the blood in some cavity, or between loose connective tissue. The great cavities of the body, as the chest and abdomen, may contain, as the result of disease, large quantities of fluid. Inflammation of the pleura is followed by effusion of fluid into the chest, and this is known as dropsy, or water in the chest. Abdominal dropsy or ascites may be so pronounced that a novice will discover it by the distended walls of the belly. As with the chest so with the abdomen, it is usually the result of disturbance of an organ and interrupted circulation. Anything which interferes with the portal circulation of the liver is likely to result in dropsy, or accumulated fluid in the abdominal cavity; the most familiar example of dropsy is that of the pot-bellied, razor-backed sheep long afflicted with fluke or liver rot. After any debilitating illness, and particularly those diseases of the blood in which its red corpuscles are broken up, there is a tendency to dropsical effusions. Dropsical swellings or effusions into the limbs of animals are not of such serious import as in mankind, and it is a matter of common observation that 'filled' legs will fine or become normal with only a moderate amount of exercise. *Treatment* of dropsy, then, will be determined by the cause, which must be sought, and if possible removed. In the examples quoted, treatment will be directed to the pleura (see PLEURISY), to the liver (see LIVER, DISEASES OF), to the destruction of parasites (see FLUKE), and to the rebuilding of the blood corpuscles and strengthening of the system by tonics and suitable aliment. The dropsical swellings of horses' limbs are due to a number of causes besides debility, and are frequently removed by the use of so-called diuretics, which call upon the emunctories to perform additional work, the kidneys being specially active in carrying off the excess of fluid which has escaped through the bloodvessels into the loose areolar tissue of the lower portions of the limbs. Dropsical accumulations are sometimes removed by the aspirator from joints, under special aseptic conditions, and from the chest and belly by the trochar and canula. [H. L.]

Dropwort. See ŒNANTHE.

Drosera. See SUNDEW.

Drosophila flava (the Yellow Turnip Leaf Miner) is a minute fly which lays its eggs on the leaves; the maggots produced from them eat into the pulp, and form large whitish blisters on the upper side. When full grown they are pale-green, and change to chestnut-coloured pupæ, with two small horns at the head, and from these the flies are produced. They are ochreous, with black hairs, and two little feathered horns; the eyes are black; there are three ochreous

Drosophila flava (Yellow Turnip Leaf Miner)

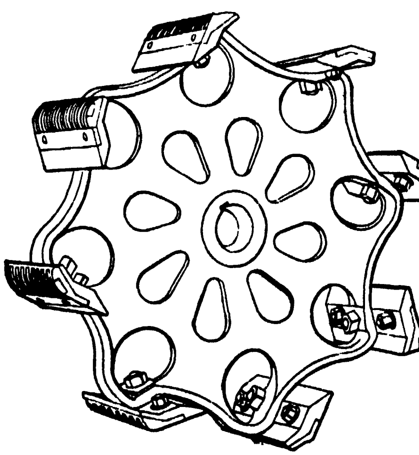
1, The mined leaf 2, The concealed grub 3, The grub magnified 4 and 5, The pupa, natural size and magnified. 6, The fly magnified. 7, Its natural size.

stripes down the trunk; the six legs and two balancers are yellowish and downy; the two wings are large and iridescent. [J. C.] [C. W.]

Drought.—The result of drought on soil and crops and the means of mitigating its effects are considered under SOIL. See SOIL, WATER RELATIONSHIPS OF.

Drover.—A man who drives cattle or sheep to a distant market is known as a drover. Before the spread of railways and when markets were fewer, the drover's was a distinct occupation, but the more rapid means of transit and spread of markets have enabled farmers and the dealers to dispense with his services.

Drum.—Drums in conjunction with open sparred concaves form the essential parts of the



Section of Drum of Threshing Machine.

threshing machine, because it is between these that the corn is threshed. The drum is carried on the main spindle, at the end of which is the driving pulley, and extends the greater width across the threshing machine. The illustration

shows a section of a drum, in which the mode of attachment of the ribbed beaters is shown. The beaters extend the width of the drum, and it is these which thresh out the corn against the concave. The face of the beaters is made wide because the operation is not merely one of beating out corn by concussion, but by rubbing it against the concave; the ribbing permits this without cracking the grain. The drum is made heavy, entirely of steel and iron, which ensures even running and thorough threshing. The space between the concave and drum is regulated by adjusting the concave to the beaters, the drum having a fixed position, and indicator plates are fitted to show when the concaves are exactly parallel with the drum. Drums are fitted with guards, which admit the free passage of the sheaves of corn, but prevent the feeder from falling on to the beaters. See THRESHING MACHINE. [W. J. M.]

Drumlin, a name of Celtic origin, originally applied in the north of Ireland to elongated mounds of glacial drift. These mounds may be 100 ft. high; they have a parallel arrangement over considerable areas, and consist of unstratified boulder clay. Drumlins result from the deposition of material carried within a great ice sheet, and left by it as it slowly melted away. Their parallel arrangement is due to the movement of the ice in some particular direction. The rock floor beneath them is striated, and sometimes the drumlin has been deposited about a core of rock over which the land-ice rode. The boulders retain the scratches received by them when embedded in the ice sheet; they are sometimes angular blocks, and are not water-worn as in eskers (see art. ESKER). Drumlins form typical 'hogs' backs', often tilled with success amid otherwise rocky country, and draining well owing to the numerous stones and the steepness of their flanks. The soil of drumlins becomes a stiffer loam or clay towards the base, in consequence of the washing down of the finer particles by rain. See M. H. Close, Journ. R. Geol. Soc. Ireland, vol. i, 1867, pp. 212 and 236; Jas. Geikie, Great Ice Age, 3rd ed., 1894, pp. 81 and 743. [G. A. J. C.]

Dry Farming.—In semi-arid regions, where the rainfall is under the normal, the practice of growing crops without the help of irrigation is known as dry farming. Dry farming is most extensively practised in the Great Plains area —the dry belt of America, and in recent years land hitherto unproductive has been made to yield remunerative crops as the result of a combination of factors which together constitute the science of dry farming. These consist in the conservation of soil moisture by improved methods of cultivation, the growing of crops suited to their environment, and the employment of seed of special drought-resisting varieties of these crops. The principles underlying the practice of dry farming are based on the movements of water in the soil, and the aim of the methods described below will only be grasped after a clear conception of these movements has been formed. In this connection the reader should consult the section of the art. on SOIL which deals with its water relationships, &c., and also the art. on CULTIVATION, CHEMICAL AND PHYSICAL EFFECTS OF.

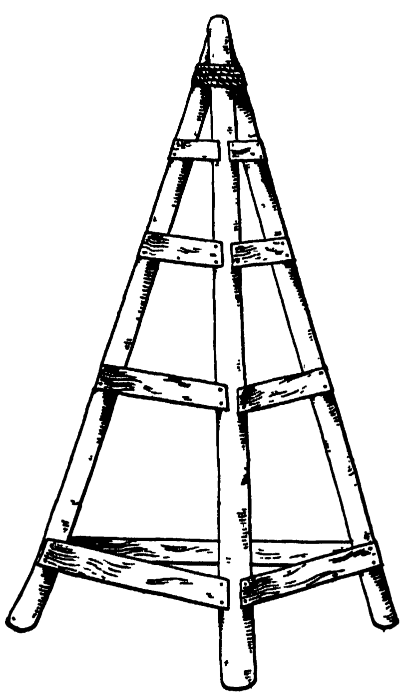
The first essential condition in successful dry farming is that the soil should be deep and retentive, and should be properly tilled. Ploughing is the most important of the whole series of operations, as on it depends the store or reservoir for the soil water. In America a deep ploughing is given in the fall before the rainy season sets in, and it is customary to precede the ploughing by a disk harrowing. Double disking the land as soon as the crop is removed conduces to the formation of an excellent mulch, and prevents the loss of large quantities of moisture between the time of the removal of the crop and the ploughing of the land. The depth of ploughing recommended is from 6 to 8 in., and this should, when time permits, be followed by the sub-surface packer or fluted roller, an implement something like the furrow presser, and which has the effect of firming and pulverizing the under portion of the furrow slice, but leaving the top loose and rough. By firming the under surface in this way the amount of water retained by the soil is increased. The sub-surface packing is immediately followed by harrowing. All these operations should, if possible, be performed in one day. Level culture and the formation of a fine surface top have proved the best means of preventing evaporation and conserving the soil moisture. The surface mulch thus obtained should be renewed as often as possible, and especially after every heavy rainfall, as soon as the soil is dry enough to work without danger of puddling or forming clods. Ploughing is followed by seeding. The seeds should be drilled rather deeply, and should be deposited at least 1 in. in the moist soil, which may mean 3 or 4 in. below the surface if the dry dust mulch be included in the measure. If there is any danger of the surface soil being too dry at the time of sowing the seed, the soil should be rolled and harrowed again after brairding. Harrowing should be repeated at frequent intervals to prevent the formation of a crust on the surface and the consequent loss of water by evaporation. The seeding may either be done in the fall or in the spring, the time of seeding depending on the time of the dry season and the distribution of the rainfall. If spring seeding is practised and the land ploughed in the fall, it is necessary to give the land a light harrowing early in spring, and to follow this by a deeper cultivation. The amount of seed required in the practice of dry farming is always less than in ordinary circumstances, and is dependent on the amount of soil moisture available for the crop. The lower the rainfall, therefore, the less the quantity of seed that should be sown. About half a bushel per acre is usually sufficient in the case of wheat. After seeding frequent cultivation is necessary for success, and should be indulged in as long as it will not injure the growing crop.

In dry-farming areas continuous wheat growing is largely practised, and a fixed rotation is rarely observed. Suitable crops are the cereals, sorghums, millet, certain leguminous crops, and sometimes sugar beet. Of cereals, wheat is the

most commonly grown, the Durum varieties being best adapted. Spelt wheat, oats, rye, and barley can all be grown. Barley is probably the least suitable on account of its shallow-rooted habit of growth. Of the sorghums, fodder cane, Kaffir corn, and doura are most commonly grown. They should be sown for hay, and drilled or planted in double rows about 8 in. apart, and cultivated between the drills. One of the best crops to sow in the spring is millet, because it is capable of growing and maturing on a very small amount of moisture, and because its period of growth is short. Of leguminous crops lucerne is the most suitable, though peas and beans are also grown. It is generally necessary to precede the growth of the lucerne crop by a summer fallowing, in order to ensure sufficient moisture and perfect germination. The seed should be sown and drilled somewhat deeply.

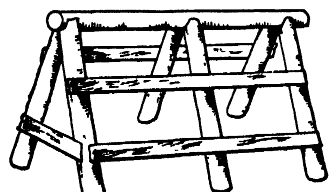
In the employment of such a system one cannot expect very large yields. The average wheat return is put at 15 bus., and lucerne at from 1½ to 2 tons. But it must be remembered that dry farming is practised only in areas where land is very cheap, and where farming is carried on on an extended scale. It is evident that all farming operations must be done on an extended basis to prove remunerative, and special labour-saving machinery must be employed. [R. H. L.]

Drying Racks.—Drying racks for assisting the drying of crops in unfavourable seasons



Pyramidal Boss

are of two types—one for drying before stacking, and the other for drying in the stack. Except when dealing with but small quantities of material, field racks are of little use; small quantities can be dealt with by being set against a frame or fence in such a way as to give free access of air about the sheaves; but unless a roofing, as of corrugated iron, is provided, there is little gained beyond what would be secured in a well-capped stook or shock,—in fact the latter is preferable. Somewhat elaborate forms of racks have been devised in which sheaves are laid on horizontal wires strained from posts which carry a light roof; and it would be difficult to suggest a better method, except that so much accommodation has to be provided for so small a quantity of corn saved. For valuable seed such a rack might give a profitable result,



Trestle

but it would be rare where the outlay would be met when dealing with an ordinary farm crop. Racks to ventilate corn stacks are used with distinct advantage, though it is very rare that there is need for them in the drier climates in England, where corn can be stacked in stacks of almost unlimited size without heating in all ordinary seasons. In moister climates they are useful and almost necessary. The under ventilation secured when corn is placed on a staddle greatly facilitates drying, and when a boss or light open framework of wood is fixed at the centre so as to ensure internal ventilation and prevent too much consolidation at the centre, corn otherwise too raw for stacking may be safely stacked. The boss is usually made in pyramid or prismatic form. When the stack is built upon the ground, under ventilation may be secured by placing a sow or stout wooden trestle made A-shape to connect from the outside to the boss. Stout square frames are sometimes used, having sufficient strength to carry a considerable portion of the roof. Any structure, however, which ingenuity suggests to keep free ventilation and prevent consolidation may be employed with advantage; and it is obvious that the larger the stack the greater need for relief. The size of the stacks found in different localities is a pretty good guide to the climate. See also GRAIN DRYING SHEDS. [W. J. M.]

Dry Matter is the material left after the water has been evaporated from vegetable or other substances. It comprises the solid portion of plants and animals, and is composed of both organic and inorganic substances. It is prepared by drying the fresh material at a temperature between 50–100° C. The composition of the dry matter varies according to its source. In the case of vegetable substances the greater part of the dry matter is composed of organic compounds, and the proportion and kind of

substances present depends upon the species of plant, part of plant, state of maturity, &c. In bones the inorganic material forms the largest proportion. [R. A. B.]

Dry Rot of Timber, a process of decay during which timber loses its fibrous nature and becomes dry, brittle, powdery, and incapable of bearing weight. No disease of timber has caused so much loss in buildings, and as it is difficult to fix responsibility between owner, builder, and timber merchant, much litigation has resulted. What is generally recognized as dry rot is caused by fungi, but somewhat similar damage may be due to beetles and other insects. The fungus known particularly as the 'dry-rot fungus' is *Merulius lachrymans*, one of the Polypore fungi (see FUNGI—'Polyporeæ'). At first the fungus filaments are concealed in the timber, and so act on it that it becomes brown and absorbs moisture readily, frequently becoming so wet that drops exude, hence the name *lachrymans* or weeping. When the timber becomes dry, numerous cracks are formed, so that it appears split into small squares. If the air is moist, the fungus becomes visible as a loose white coating like cotton wool on the surface of the wood. At a later stage this coating assumes an ashy-grey colour, and forms felted sheets or narrow strands on the wood. The spore-bearing bodies appear as shallow saucers with a wrinkled surface; at first they are white or yellow, but when the spores are mature the surface becomes rusty-brown. The odour of the fungus is also characteristic. This fungus has rarely been observed in forest timber, and it is generally considered that sound timber becomes infected by contact in woodyards or buildings. Dry rot caused by other fungi may be introduced from the forest (see PINE—'Red Rot'). All forms of dry rot are favoured by damp and lack of ventilation. [W. G. S.]

Whenever wood as part of a building is allowed to remain under the influence of damp, and is at same time shut off from light and air, there, if the temperature be not too low, will the fungus be liable to gain a footing. The inference, therefore, is to use dry or seasoned wood, to provide against its being subject to dampness, and to promote the circulation of air about the wood so far as practicable. Where ventilation cannot very well be induced, it is advisable to dispense with wood and use iron or steel. It is only where wood is being used for the purpose of support that ventilation is somewhat impracticable, and in an instance of this sort the girder is usually more satisfactory than the beam. The fungus eschews light, hence its grip of a place before the inexperienced are aware of its presence. Under floors, behind wainscot and lining, and on 'safe' lintels it may be at work without them knowing. But he who knows it of old can early tell of its existence in these lurking places. Its smell alone betrays its presence to him. Other signs there are, however, that reveal to him what is taking place behind the scenes. We have seen a house in which the fungus, after overrunning the flooring joists or sleepers on the ground floor, had crept up the strapping and lathing of the outer walls till it gained the roof timbers, enveloping the first-floor joists as it passed, and thus had the whole building in its grasp before the inmates were made aware of what was happening. The mild and moist climate of the west of Britain seems to be conducive to the growth of this fungus. A complete gut out and a thorough disinfection is accordingly the only step in the case of dry rot in a building. A good sprinkling of powdered quicklime to walls and basement ground around the seat of attack, and a liberal application of corrosive sublimate to the new wood, is essential in repairing after an outbreak; and of course a due attention to the simple rules for prevention quoted above. [R. H.]

Dry Warping, a method of improving land by spreading a layer of a better soil over a poorer. It is distinguished from Warping in which the coating of soil is deposited by water. See WARPING.

Ducks, Breeding and Rearing of.—The various utility breeds of ducks are divided into two classes, namely, flesh producers and egg producers; the breeding of the former offers better returns for labour and skill involved, and is therefore more commonly followed. The demand for table ducks varies with the season. Hence we have the early or spring duckling trade during the first six months of the year, and the autumn trade during September and October. Though the breeds of ducks are dealt with elsewhere, it may be here mentioned that the Aylesbury or the Pekin-Aylesbury crosses are used for the spring trade, the Rouen for the autumn demand, and the Pekin and the Indian Runner for egg production. The Cayuga and the Huttegem are more employed for private use than market requirements.

One of the most important factors in breeding stock ducks is the age of the parents, and yet it is a point which is frequently overlooked. The strongest stock is that produced by second-season ducks mated with good yearling drakes, allowing three or four females to each male. The eggs laid during the first season should be hatched only when the progeny are destined for the market, as in this case immaturity in the parents does not influence results to the same extent, and, moreover, eggs are obtained earlier from younger birds—a very essential feature when spring ducklings are desired.

The stock ducks should be mated up about December, a useful number being a 'pen' comprising ten ducks and three drakes, and hatching should commence in March and be continued until the early part of May. For housing, no special provision need be made. A useful structure is one 6 ft. long by 4 ft. deep, 4½ ft. high in front, sloping to 3½ ft. high at the back. The cheapest material to use is timber, and this should be ¾ in. in thickness. The top foot of the front is best covered with wire netting, as this ensures sufficient ventilation. No perches or nests are fitted. Wherever possible, the birds should have their liberty, with free access to water, but a run should be attached to the house in which they can be confined until after they have laid, which usually happens about eleven o'clock in the morning.

The feeding of the stock ducks plays a very important part in determining the number of eggs laid, for unless suitable foods be given the birds will not obtain the requisite constituents for the formation of their eggs. When the weather is at all cold the first feed of the day should consist of mash slightly warmed; on no account should it be fed cold, because if a quantity of cold food is taken into the system it results in a considerable waste of animal heat, which has the effect of reducing the supply of eggs. The mash should consist of meals, together with household scraps and a little farm or garden produce, cooked or well soaked. For winter use barley meal is perhaps the most suitable, but it is advisable, in order to obtain a balanced ration, to give a mixture. A little maize may be supplied with good results, for although a bad food when fed alone, yet when given in conjunction with other meals its effect is beneficial. The following is a good mixture and can be recommended: Barley meal 3 parts, middlings (toppings, thirds, pollard or sharps) 2 parts, maize meal 1 part, and during open weather, bran 1 part, together with whatever house scraps may be available. If the latter are unobtainable, ½ part of granulated meat should be substituted. Some breeders use grain for the afternoon feeding, but we have always obtained better results by repeating the morning mash. If grains are used the most suitable are oats, wheat, and a little maize, but they should be soaked before feeding.

For hatching, either hens or incubators may be used, though if the artificial system is adopted special precautions must be taken (see INCUBATION). The incubation period is twenty-eight days. As soon as the hatch is over, the ducklings should be placed in a roomy coop or brooder. The youngsters require very little brooding, but must be provided with shelter against sun, rain, and wind. The best foods are biscuit meal, soaked in boiling water until soft, dried off with barley meal (fine), toppings, or ground oats, and for the first week this should be given every three hours. After a week the biscuit meal may be dispensed with, the other meals being used, together with the addition of 15 per cent of granulated meat, and be fed five times a day. This is continued for three weeks, when only four feeds per diem need be given, and at the same time the birds are allowed access to water for a short time each day. When the ducklings are from seven to eight weeks old, if fed in the morning, at midday, and again in the evening, and given full liberty, it will be sufficient. This treatment can be followed all the summer, the amount of food given varying with the quantity of natural food which the ducks can gather for themselves. Grit, water, and green food must be given in abundance.

As the demand for ducklings is mostly in the spring of the year, the following particulars as to production for market are appended. The counties of Buckinghamshire and Bedfordshire have long been famous for the production of early ducklings, and until recently the trade has been almost entirely concentrated in these districts. Owing to the concentration of the industry in these two counties, the idea has become prevalent that there must be some special climatic conditions, or some characteristics of the soil or location, especially favourable to the production of early ducklings. This, however, is not the case, and now, scattered up and down the country, duck farms have been established with, in some instances, excellent results, while a host of farmers and smaller occupiers of land keep a few breeding ducks, and although perhaps not specially devoting themselves to the production of market birds, yet they succeed in preparing a few of good quality.

The rearing of ducklings is almost entirely in the hands of cottagers and small farmers, the large establishments being exceedingly few and far between. Moreover, generally speaking, the 'duckers', as the rearers are called, rarely have much land at their disposal. One of these living near Aylesbury has in a single season hatched and reared upwards of 2300 ducklings on a holding of scarcely half an acre. To rear stock ducks under such conditions would be injudicious, but when they are to be killed as soon as they are sufficiently large no harm ensues, as it is immaterial whether they possess sound constitutions so long as they fatten and kill well. It is almost needless to say that utmost cleanliness has to be observed, and every precaution taken to prevent disease, for with so many birds in so small a space the results might be most disastrous. As would be naturally expected, the duck-rearers rarely attempt to maintain any regular breeding stock, but purchase the required eggs from farmers living in the neighbourhood, who have an abundance of space at their disposal and can allow the stock birds full liberty. As a general rule, the eggs are arranged for by contract from the beginning of November until the end of March or April; the price commonly agreed upon is 3*s.* to 3*s.* 6*d.* per dozen throughout this period. When, however, no contract is entered into, very high prices are sometimes procurable during December and January; frequently 10*s.* per dozen has to be paid, and during a spell of severe weather often as much as 12*s.*—this, be it remembered, for eggs from ordinary utility stock, not exhibition birds in any sense of the term. How it is possible for the duck-rearers to pay these high prices for their eggs and yet secure a generous profit, will be evident presently when the sale prices of ducklings are quoted.

In the Vale of Aylesbury, hens are used largely for hatching, but in other parts of the country incubators are more frequently employed. Ducklings require very little brooding, being extremely hardy, and the hen or the lamp may be dispensed with after five days or a week. At the end of this time the best plan is to place them in flocks of about twenty to twenty-five, housed in a large roomy shed. The flocks can be divided from one another by low boards some 18 in. high, which is sufficient to keep the birds apart, but low enough to step over, thus dispensing with gates. It is all the better if the front of the shed is open, so that the ducklings are sure of obtaining pure fresh air. In that case some arrangement would have to be made for lowering a shutter or canvas curtain on cold nights

for purposes of protection. When the ducklings are destined for market the less exercise they obtain the better, and thus from the very first they should be closely confined. Moreover, they should not have access to water, save the day before killing, when a swim cleanses the feathers and adds to their value.

Much of the ultimate success achieved depends upon the foods employed during the early stages, and thus special care has to be exercised in this direction. For ducklings intended for the market forcing foods should be used, in order to encourage development as much as possible, because every day that can be saved is of importance, especially when prices have attained their maximum or are on the decline, when a week or ten days may make a difference in price of several shillings per pair. Variety in feeding is one of the secrets of success in raising ducklings, hence as large a number of suitable foods should be used as price and opportunity allow. During the first few days, hard-boiled eggs, chopped finely and mixed with bread crumbs or biscuit meal, should form the chief food. This should be moistened with skim milk and fed in a fairly dry state, not sloppy. On barley meal and middlings, mixed in equal proportions, the birds thrive well, besides which it is a comparatively cheap mixture. There is, however, no more suitable food for ducklings at all stages than rice. It is useful for rearing and for fattening, it is cheap, and the birds develop quickly thereupon. It requires to be carefully prepared, otherwise it may have an injurious effect. To 1 part of rice 3 parts of water should be added, and the two allowed to simmer on a fire until the rice has soaked up all the liquid, which it will do in a few hours. Burma rice is the best, and costs about 8*s.* per cwt. If the ducklings are backward, one feed a day of oatmeal will bring them on amazingly. For the first fortnight four feeds a day should be given, and after this period three feeds a day will prove sufficient. The meals should be given at regular intervals—the first about 6.30 in the morning, the second at midday, and the third about 5.30 or 6 o'clock at night. The food should be fed in troughs, and remain before the birds for some twenty minutes, when it should be removed and the birds allowed no more until the next meal time comes round. It is a very bad plan to permit food always to be before the birds, as it injures their appetites.

When the ducklings are about five weeks old, fattening should commence. This period lasts three weeks, and thus the birds are ready for killing when eight weeks old, at which age each will weigh from 4½ to 5½ lb. The ducklings during this fattening period are best divided into flocks of about twenty-five, those as even in age as possible being penned together. The finest food for fattening is rice, with the addition of a little fat. This fed three times a day produces the finest flesh of first-rate quality and flavour. Those who supply a second-class trade employ middlings and barley meal, others again use maize, but the latter tends to produce a soft yellow fat which is very undesirable. Green food and grit must be regularly supplied, without which good results cannot be achieved. Before killing, the birds should be starved for twenty-four hours, so that the digestive tract may be emptied, a point which improves both the flavour of flesh and its keeping qualities. Killing is generally done by dislocation of the neck, and if the bird is plucked at once the head should be hung downward during this operation. When the feathers have been removed, the birds should be placed on a table and heavily weighted. When quite cold they can be packed in clean boxes between layers of sweet straw. The prices obtained for early ducklings are exceedingly high, and no branch offers greater inducements to poultry keepers. The following prices were realized during the year 1907 in the London market, the lower indicating the poorest quality, and the higher the finest quality: January, 5*s.* 6*d.* to 10*s.* per pair; February, 6*s.* 6*d.* to 12*s.*; March, 10*s.* to 18*s.*; April, 8*s.* to 10*s.*; May, 6*s.* to 8*s.*; June to December, 5*s.* to 7*s.* [W. BR.]